1 of 1

Solar Collector Manufacturing Activity 1992

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Energy Information Administration
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MASTER

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Preface

The *Solar Collector Manufacturing Activity 1992* report prepared by the Energy Information Administration (EIA) presents data provided by U.S.-based manufacturers and importers of solar collectors. Summary data on solar thermal collector shipments are presented for the years 1974 through 1992.¹ Summary data on photovoltaic cell and module shipments are presented for the years 1982 through 1992. Detailed information for solar thermal collectors and photovoltaic cells and modules are presented for 1992. The 1992 data were collected on Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey," and Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey." The standard unit of measure for solar thermal collectors is square feet of collector surface and for photovoltaic cells and modules is peak watts (see Glossary).

Appendix A of the report describes the survey methodology. Appendix B contains the 1992 survey forms and instructions. Appendices C and D list the companies that responded to the 1992 CE-63A and CE-63B surveys and granted permission for their names and addresses to appear in the report. Appendix E provides selected tables from this report with data shown in the International System of Units (SI) metric units.

Appendix F provides an estimate of installed capacity and energy production from solar collectors for 1992.

This report provides annual data necessary for the Department of Energy to execute its responsibilities to (1) monitor activities in the solar collector industry, (2) implement the National Energy Strategy, and (3) provide information on the development and status of the industry to the Congress, Federal and State government agencies, solar energy manufacturers and specialists, universities and research institutes, and to the general public.

The EIA and its predecessor organizations began conducting voluntary telephone surveys of the solar thermal collector industry in 1975 to monitor manufacturing activities. The first survey collected data for 1974, and subsequent surveys were conducted semi annually through 1981. Since 1982, the surveys have been conducted annually. The sole exception was 1985, when the Form CE-63A survey was not conducted. Mandatory reporting of data on Forms CE-63A and CE-63B was specified under Public Law 93-275, and it was initiated with the data collection for the period July through December 1978.

¹Data for 1985 were not collected until 1987 and are considered incomplete. Comparisons of the available 1985 data with similar data for 1984 and 1986 are provided in Appendix A.

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1992 Highlights

Solar thermal collector shipments totaled 7.1 million square feet in 1992, compared with 6.6 million square feet in 1991. An 11-percent increase in shipments of low-temperature collectors, used primarily to heat residential swimming pools, was responsible for this growth. Shipments of low-temperature collectors increased in 1992 to 6.2 million square feet from 5.6 million square feet in 1991. Shipments of medium-temperature collectors declined from 1 million square feet in 1991 to 0.9 million square feet in 1992, a 9 percent decrease (Figure H1). The number of companies that shipped solar thermal collectors also declined

from 48 in 1991 to 45 in 1992, the same number as in 1974.

The total value of solar thermal collector shipments in 1992 was \$25.4 million, a 9-percent decrease from 1991. This decrease was due in part to a drop in the average price per square foot of low-temperature collectors, which decreased 14 percent to \$2.49 per square foot in 1992 from \$2.90 per square foot in 1991.

For the last 4 years (1989-1992), solar thermal collector shipments to the commercial sector have been declining, while shipments to the residential sector have been steadily increasing. Shipments of low-temperature solar thermal collectors have experienced an overall increase from 1990 through 1992, but shipments in that same period of medium-temperature solar thermal collectors have declined.

At the end of 1992, 27 States provided some financial incentives for investment in the use of solar thermal collectors and photovoltaic modules and cells, compared with 15 States in 1991. The legislative actions were passed to encourage the use of an environmentally clean source of energy, to promote energy conservation through the use of renewable energy technologies, and to increase energy efficiency. Among the most common incentives were property tax exemptions and income tax credits for both the residential and business sectors.

In 1992, California, New York, New Jersey, Florida, and Puerto Rico accounted for 98 percent of the total manufacturing of solar thermal collectors. California accounted for more than 50 percent of the total number of solar thermal collectors manufactured in both 1991 and 1992. Industry wide, the top five destinations for shipments were Florida, California, Arizona, Hawaii, and Puerto Rico. Florida and California together received 83 percent of all shipments to U.S. and U.S. territories.

Shipments of photovoltaic cells and modules (Figure H2) totaled 15.6 peak megawatts in 1992, an increase of 4 percent, compared with the 14.9 peak megawatts in 1991. The total value of photovoltaic cell and module shipments in 1992 was \$87.1 million, a small increase from the value of shipments in 1991 (\$86.7 million).

Figure H1. Solar Thermal Collector Shipments by Collector Type, 1981-1992

Note: Data for 1985 are incomplete and are not shown.

Sources: **1981-1984**—Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." **1985-1992**—Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Figure H2. Domestic and Export Shipments of Photovoltaic Cells and Modules, 1985-1992

Note: Domestic shipments equal total shipments minus exports.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Approximately 10 peak megawatts were exported in 1992, an increase of 10 percent from the 1991 level. Since 1987, the annual amount of export shipments has exceeded domestic shipments.

Shipments of photovoltaic cells and modules for the period 1988 through 1992 have been increasing at an average annual rate of 10 percent. Shipments to the commercial sector have declined 61 percent since 1990, but shipments to the residential sector have increased 40 percent over the same period of time. The average price (dollars per peak watt) of all types of photovoltaic modules has decreased slightly since 1985 mainly as a result of a marked decline in the average price of concentrator modules and cells. This decline was mainly due to increased volumes of shipments of concentrators in 1992.

EIA estimates that solar thermal collectors and photovoltaic modules and cells provided approximately 0.06 quadrillion Btu of energy production in the United States during 1992 (see Appendix F).

Solar Two is a 10-megawatt central receiver pilot plant in Barstow, California. This project, led by Southern California Edison, is cost-shared by DOE, several major western utilities, EPRI, Bechtel, and the South Coast Air Quality Management District.

1. Solar Thermal Collector Manufacturing Activities

This chapter presents information on the statistics of the solar thermal collector manufacturing industry in 1992. Solar thermal collector shipments, origins and destinations, imports, exports, collector types, values and prices, and uses and market sectors are presented. Data on solar thermal collector shipments include both imported collectors and collectors manufactured by U.S.-based companies that were shipped for domestic use and for export.

Industry Status

Forty-five companies were active in the solar thermal collector manufacturing industry in 1992. These 45

companies shipped collectors totaling 7.1 million square feet in 1992 (Table 1). Of the 45 companies, 5 plan to introduce new high-temperature collectors in 1993, and 12 plan to introduce new medium-temperature collectors (Table 2).

From 1984 to 1986, the number of manufacturing companies declined by 127 (Table 1). At the end of 1985 the 40-percent residential energy tax credit and the 15-percent business energy tax credit expired. The decline in industry companies intensified with the drop in oil prices in 1986. The reinstatement of the business energy tax credit at the 15-percent level for 1986, at the 12-percent level for 1987 through 1991, and at the 10-percent level in 1992, plus increasing oil prices after

Table 1. Annual Solar Thermal Collector Companies and Shipments, 1974-1992
(Thousand Square Feet)

Year	Number of Companies	Solar Thermal Collectors		
		Total Shipments	Import Shipments	Export Shipments
1992	45	7,086	1,650	316
1991	48	6,574	1,543	332
1990	51	11,409	1,562	245
1989	44	11,482	1,233	461
1988	51	8,174	814	158
1987	59	7,269	691	182
1986	98	9,360	473	224
1985 ^a	NA	NA	NA	NA
1984	225	17,191	6,31	348
1983 ^b	203	16,828	511	159
1982 ^b	265	18,621	418	455
1981 ^b	203	20,133	196	771
1980 ^b	233	19,398	235	1,115
1979	349	14,251	290	855
1978	340	10,860	396	840
1977	321	10,312	NA	NA
1976	186	5,801	NA	NA
1975	131	3,743	NA	NA
1974	45	1,274	NA	NA

^aIncomplete data (see Appendix A).

^bIncludes imputation of shipment data to account for nonrespondents (see Appendix A, pages 24 and 25).

NA = Not available.

Note: Total shipments include import and export shipments.

Sources: **1974-1977**—Federal Energy Administration telephone survey. **1978-1984**—Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." **1985-1992**—Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 2. Number of Companies Expecting to Introduce New Solar Thermal Collector Products In 1993

New Product Type	Number of Companies
Low-Temperature Collectors	5
Medium-Temperature Collectors	12
High-Temperature Collectors	5
Non-Collector Components	5

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

1986 appear to have had little effect on drawing companies into manufacturing solar thermal collectors.

At the end of 1992, 27 States provided some financial incentives for investment in the use of solar thermal collectors and photovoltaic modules and cells, compared with 15 States in 1991.² The legislative actions were passed to encourage the use of an environmentally clean source of energy, to promote energy conservation through the use of renewable energy technologies, and to increase energy efficiency. Among the most common incentives were property tax exemptions and income tax credits for both the residential and business sectors.

For the period 1986-1991, the 10 largest U.S. companies in terms of collector shipments have supplied between 91 and 97 percent of all solar thermal collectors manufactured in or imported into the United States (Table 3). In 1992, 95 percent of the 7.1 million square feet of total shipments were supplied by the 10 largest companies. In the period 1982 to 1984, the average share of the 10 largest companies was 50 percent of total shipments.

Employment in solar thermal-related activities totaled 449 person-years in 1992 (Table 4), an increase of 111 person-years from the 1991 employment level. The average employment per company was 10 person-years, compared with 7 person-years in 1991. For 1992, the range in employment levels for about 50 percent of the companies was 1 to 5 person-years.

Most of the 45 reporting companies in 1992 combined other related activities with the manufacturing or importing of solar thermal collectors: 35 companies were involved in collector or system design, 18

Table 3. Percent of Solar Thermal Collector Shipments by the Ten Largest Companies, 1982-1992

Year	Company Rank	Shipments (thousand square feet)	Percent of Total Shipments
1992	1-5	6,110	86
	6-10	609	9
	1-10	6,718	95
1991	1-5	5,429	83
	6-10	829	13
	1-10	6,258	95
1990	1-5	9,955	87
	6-10	1,029	9
	1-10	10,983	96
1989	1-5	9,748	85
	6-10	1,321	12
	1-10	11,069	96
1988	1-5	7,585	93
	6-10	335	4
	1-10	7,920	97
1987	1-5	6,371	88
	6-10	499	7
	1-10	6,870	95
1986	1-5	7,771	83
	6-10	785	8
	1-10	8,556	91
1985 ^a	--	NA	--
1984	1-5	6,092	35
	6-10	2,605	15
	1-10	8,697	51
1983	1-5	5,919	35
	6-10	2,752	16
	1-10	8,671	52
1982	1-5	6,320	34
	6-10	2,560	14
	1-10	8,880	48

^aIncomplete data (see Appendix A, pages 24 and 25).

NA = Not available. -- = Not applicable.

Note: Totals may not equal sum of components due to independent rounding.

Sources: **1982-1984**—Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." **1985-1992**—Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

manufacturers were developing prototype collectors, and 20 were developing prototype systems (Table 5). Twenty-four companies were wholesalers, and 24 companies were retailers. Twenty of the 45 companies installed their collectors.

²Source: "Governments Advancing Solar Energy Across the Nation," *Solar Industry Journal*, First Quarter 1992, Volume 3(1), pp. 21-28.

Table 4. Solar Thermal Employment, 1989-1992

Year	Number of Companies	Number of Person-Years
1992	^a 45	449
1991	48	338
1990	51	850
1989	44	900

^aOne company reported zero employment.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 5. Number of Companies Involved in Solar Thermal-Related Activities by Type, 1991 and 1992

Type of Activity	Number of Companies	
	1992	1991
Collector or System Design	35	33
Prototype Collector Development ...	18	19
Prototype Systems Development ...	20	19
Wholesale Distribution	24	33
Retail Distribution	24	25
Installation	20	22
Non-Collector System Component Manufacture	16	21

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Solar-related sales represented 90 to 100 percent of total company sales for 27 companies in 1992 versus 26 companies in 1991 (Table 6). Solar-related sales made up less than 10 percent of total sales for 4 companies in 1992, compared with 8 companies in 1991.

Shipments

Solar thermal collector shipments totaled 7.1 million square feet in 1992, an 8-percent increase from the 1991 level of 6.6 million square feet in 1991 (Table 1). Import shipments totaled 1.7 million square feet and export shipments were 0.3 million square feet in 1992 (Figure 1). Shipments of low-temperature solar thermal collectors increased 11 percent in 1992 from 1991, and medium-temperature collectors decreased 9 percent. Shipments of high-temperature collectors increased from 1,000 square feet in 1991 to 2,000 square feet in 1992 (Table 9).

Table 6. Solar-Related Sales as a Percentage of Total Sales, 1991 and 1992

Solar-Related Sales as a Percent of Total Sales	Number of Companies	
	1992	1991
90-100	27	26
50-89	7	9
10-49	7	5
Less than 10	4	8
Total	45	48

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Origins

U.S. manufacturers in California, New York, New Jersey, Florida and Puerto Rico produced 98 percent of U.S.-manufactured collectors in 1992, compared with 99 percent in 1991. California continued to lead the Nation in 1992, with 55 percent of total domestic shipments. Shipments of U.S. manufactured solar thermal collectors in 1992, which totaled 5.4 million square feet, originated from 19 States and Puerto Rico. California produced 55 percent of U.S. manufactured solar thermal collectors in 1992 compared with 56 percent in 1991 (Table 7). New York, New Jersey, and Florida produced a combined 2.2 million square feet in 1992. The amount of collectors produced in Florida increased from 149,000 square feet in 1991 to 208,000 square feet in 1992, a 40-percent increase. Hawaii and Texas had shipments of over 10,000 square feet in 1992.

Distribution

Fifty percent of total shipments were sent directly to wholesale distributors and 38 percent were sent to retail distributors in 1992 (Table 8). Eighty-nine percent of export shipments were sent directly to exporters. Eight percent of total shipments were shipped directly to installers, end users, or "others."

Collector Types

Solar thermal collectors are divided into three categories:

- Low-temperature collectors provide heat up to 110° Fahrenheit through either metallic or non-metallic absorbers for applications such as

Figure 1. Solar Thermal Collector Shipments, 1978-1992

Note: Data for 1985 are incomplete and are not shown.

Sources: **1978-1984**—Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." **1985-1992**—Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

swimming pool heating and water, space, and process heating.

- Medium-temperature collectors provide heat greater than 110° Fahrenheit (usually 140 to 180° Fahrenheit) through either glazed flat-plate collectors that use air or liquid as the heat transfer medium or concentrator collectors that concentrate the heat to levels greater than "one sun." Evacuated-tube collectors are included in this category.
- High-temperature collectors are parabolic dish or trough collectors used primarily by utilities and nonutility power producers in the generation of electricity for the grid. A high-temperature solar thermal collector is a collector that operates at temperatures above 180 degrees Fahrenheit.

Table 7. Five Top Solar Thermal Manufacturing States/Territories, 1991 and 1992 (Thousand Square Feet)

Rank	Origin	Shipments ^a		Percent	
		1992	1991	1992	1991
1 / 1	California	2,985	2,818	55	56
2 / 2	New York	978	979	18	19
3 / 3	New Jersey	967	805	18	16
4 / 5	Florida	208	149	4	3
5 / 4	Puerto Rico	201	208	4	4
Subtotal		5,339	4,959	98	99
Total U.S. Manufacturers		5,436	5,031	100	100

^aIncludes domestic shipments and exports.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 8. Distribution of Solar Thermal Collector Shipments, 1991 and 1992

Recipient	Shipments (thousand square feet)	
	1992	1991
Wholesale Distributors	3,537	3,674
Retail Distributors	2,709	2,161
Exporters	280	324
Installers	192	191
End Users and Other ^a	367	224
Total	7,086	6,574

^aOther includes minimal shipments not explained on Form CE-63A.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

The average annual shipment of low-temperature collectors was 386,700 square feet per manufacturer for 16 manufacturers in 1992 (Table 9). In 1981, 75 companies manufactured low-temperature collectors, and the average annual shipment was 115,700 square feet per manufacturer. For the 34 medium-temperature collector manufacturers in 1992, the average annual shipment was 26,400 square feet. Ten years earlier, there were 248 manufacturers of medium-temperature

Table 9. Solar Thermal Collector Shipments by Type, 1980-1992
(Thousand Square Feet)

Year	Low-Temperature		Medium-Temperature		High-Temperature ^a
	Shipments	Average Annual Shipments per Manufacturer	Shipments	Average Annual Shipments per Manufacturer	Shipments
1992	6,187	386.7	897	26.4	2
1991	5,585	349.0	989	24.1	1
1990	3,645	303.8	2,527	61.6	5,237
1989	4,283	428.3	1,989	55.3	5,209
1988	3,326	415.8	732	16.2	4,116
1987	3,157	263.1	957	19.1	3,155
1986	3,751	170.5	1,111	12.8	4,498
1985 ^b	NA	--	NA	--	NA
1984	4,479	93.3	11,939	58.0	773
1983 ^c	4,853	88.2	11,975	66.9	NA
1982 ^c	7,476	122.6	11,145	44.9	NA
1981 ^c	8,677	115.7	11,456	43.6	NA
1980 ^c	12,233	154.8	7,165	28.7	NA

^aFor high-temperature collectors, average annual shipments per manufacturer are not disclosed.

^bIncomplete data (see Appendix A, pages 24 and 25).

^cIncludes shipment data imputed for nonrespondents (see Appendix A, pages 24 and 25).

NA = Not available. -- = Not applicable.

Note: Totals may not equal sum of components due to independent rounding.

Sources: **1980-1984**—Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." **1985-1992**—Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

collectors in the United States, and the average annual shipment was 44,900 square feet.

In 1983 and 1984, before the expiration of the energy tax credits at the end of 1985, medium-temperature collector manufacturers shipped just under 12 million square feet annually (Figure 2). Shipments declined to 1.1 million square feet in 1986. For the period 1986-1992, shipments of medium-temperature collectors have ranged between 0.7 and 2.6 million square feet annually.

Between 1980 and 1984, annual low-temperature collector shipments decreased from 12.2 million to 4.5 million square feet. From 1986 through 1992, shipments of low-temperature collectors ranged between 3.2 and 6.2 million square feet annually. Low-temperature collectors dominated the solar thermal industry in 1992, accounting for 87 percent of total shipments (Table 9).

Medium-temperature collectors accounted for 13 percent total collector shipments in 1992. Flat plate collectors represented 8 percent of total shipments.

Collectors that constituted sub units of thermosiphon systems or integral collector storage systems (ICS) represented 4 percent of total shipments. High-temperature collectors, shipped primarily for research and demonstration, represented a negligible percentage of total shipments in 1992.

Values and Prices

The total value of solar thermal collector shipments was \$25.4 million in 1992; a 2-percent decrease compared with 1991 (Table 10). The average price of low-temperature collectors decreased from \$2.90 to \$2.49 (dollars per square foot), and the average price of ICS and thermosiphon collectors decreased from \$19.08 in 1991 to \$12.64 in 1992. This decrease is most likely due to increased levels of shipments and concurrent lower unit costs. The average price for flat-plate collectors in 1992 increased to \$9.32 from the corresponding 1991 level of \$9.07 per square foot (Figure 3). The value of shipments includes charges for advertising and warranties. Not included are excise taxes and the cost of freight or transportation for the shipments.

Figure 2. Low- and Medium-Temperature Solar Thermal Collector Shipments, 1980-1992

Note: Data for 1985 are incomplete and are not shown.

Sources: **1980-1984**—Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." **1985-1992**—Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Uses

The largest end use for solar thermal collectors shipped in 1992 was for heating swimming pools, and it represented 88 percent of the total square feet shipped (Table 11). This application usually involved the use of low-temperature collectors. A common low-temperature pool-heating solar collector is a black plastic or rubber-like sheet with tubing through which water is circulated. The heat of the sun is directly transferred from the black absorbing material to the water circulating through the tubing to supply heat to the pool.

The second largest end use was for domestic hot water systems, which accounted for 11 percent of the total square feet shipped. Typical solar water-heating systems feature flat-plate collectors or collectors

installed in an ICS or thermosiphon system. Unlike pool-heating systems, domestic solar water-heating systems nearly always have a conventional backup (i.e., gas or electric).

Additional medium-temperature collectors were shipped for space heating and cooling, and for installation into systems that provide both space and water heating. A small amount of high-temperature parabolic dish and trough collectors were shipped for electricity generation, research, and process heating in 1992.

Markets

In 1992, the largest market for solar thermal collectors was the residential market. Solar thermal collectors shipped to the residential sector in 1992 totaled 6.8 million square feet, 96 percent of total shipments (Table 12). This market sector primarily involves the use of low-temperature solar collectors for heating swimming pools and medium-temperature collectors for water heating in residential buildings. Collectors shipped to the residential sector increased 8 percent, compared with the corresponding 1991 level. The residential sector was also the largest market in 1991. The second largest market for solar thermal collectors in 1992 was the commercial sector, which accounted for 3 percent of total shipments.

Destinations

Domestic

Solar thermal collectors were shipped to 42 States, Puerto Rico, and the U.S. Virgin Islands in 1992. In 1991, 43 States, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands received collector shipments. Eight states and the District of Columbia had no shipments in 1992. Four States (Alaska, Delaware, North Dakota, South Dakota, and Wyoming) did not receive solar thermal collector shipments in 1991 and 1992 (Table 13). The four States and one U.S. territory that received the largest amounts of solar thermal collectors in 1992, were: Florida (56 percent), California (26 percent), and Puerto Rico, Arizona, and Hawaii (3 percent each) (Table 14). All of the collectors manufactured in Puerto Rico remained on the island. The U.S. market for solar thermal collectors continued to be highly concentrated in a few States and Puerto Rico. Factors favorable for solar energy use that these States and Puerto Rico have in common are: (1) good solar insolation; (2) high electricity costs; (3) solar-promoting incentives, such as tax credits or exemptions; and (4) a demand for low technology solar pool heaters and solar domestic hot water systems.

Table 10. Quantity, Value, and Average Price of Solar Thermal Collector Shipments by Type, 1991 and 1992

Type	1992			1991		
	Quantity (thousand square feet)	Value (thousand dollars)	Average Price (dollars per square foot)	Quantity (thousand square feet)	Value (thousand dollars)	Average Price (dollars per square foot)
Low-Temperature						
Liquid and Air	6,187	15,403	2.49	5,585	16,206	2.90
Medium-Temperature						
Air	1	8	11.57	W	W	W
Liquid						
ICS/Thermosiphon	303	3,825	12.64	260	4,965	19.08
Flat Plate	584	5,441	9.32	703	6,375	9.07
Evacuated Tube	W	W	W	W	W	W
Concentrator	W	W	W	1	275	218.79
All Medium Temperature	897	9,831	10.96	989	11,807	11.94
High-Temperature						
Parabolic Dish and Trough	2	148	75.66	1	23	31.94
Total	7,086	25,382	--	6,574	28,036	--

W = Data withheld to avoid disclosure. ICS = Integral collector storage. -- = Not applicable.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Figure 3. Average Price of Solar Thermal Collectors, 1991 and 1992

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Export

Exports accounted for 4 percent of total shipments in 1992. Sixteen companies exported solar thermal collectors compared with 13 companies in 1991. Of total 1992 exports, low-temperature collectors accounted for 20 percent and medium-temperature collectors 80 percent. Summed by continents, the largest percentage of shipments were to North America (51 percent), followed by Asia (31 percent) and Europe (14 percent) (Table 15). Trading countries that received export shipments were Taiwan (25 percent), Mexico (10 percent), Canada (6 percent), the Bahamas (6 percent), and Guatemala (5 percent) (Table 16).

Systems

Of the 45 companies reporting shipments of solar thermal collectors in 1992, 35 reported shipments of 15,946 complete solar thermal collector systems. This was an 8 percent increase compared with 1991 (Table 17). A complete system is a unit with a collector and all the necessary functional components, except for installation materials. Included are thermosiphon systems, integral collector storage systems, packaged systems, and system kits. The 15,946 complete systems accounted for 2.8 million square feet of collectors, an increase of 24 percent in square feet shipped, compared with 1991. The total value for the systems shipped in 1992 was \$19.4 million, compared with \$19.5 million in 1991.

Table 11. Shipments of Solar Thermal Collectors by End Use and Type, 1991 and 1992
(Thousand Square Feet)

End Use	Low-Temperature	Medium-Temperature					High-Temperature	1992 Total	1991 Total
	Liquid/Air	Air	Liquid				Parabolic Dish/Trough		
	Metallic and Nonmetallic		ICS/Thermosiphon	Flat-Plate (Pumped)	Evacuated Tube	Concentrator			
Pool Heating	6,177	0	0	34	0	0	0	6,210	5,535
Hot Water	0	(s)	276	516	W	W	0	801	989
Space Heating	10	(s)	25	0	(s)	0	0	35	24
Space Cooling	0	0	0	0	W	W	1	1	2
Combined Space and									
Water Heating	0	0	0	4	(s)	0	0	5	3
Process Heating	0	0	2	29	0	0	(s)	32	12
Electricity Generation	0	0	0	(s)	0	0	(s)	1	1
Other	0	0	0	0	0	0	1	1	1
Total	6,187	1	303	584	W	W	2	7,086	6,574

(s) = Less than 500 square feet. ICS = Integral Collector Storage. W = Data withheld to avoid disclosure.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 12. Shipments of Solar Thermal Collectors by Market and Type, 1991 and 1992
(Thousand Square Feet)

Market Sector	Low-Temperature	Medium-Temperature					High-Temperature	1992 Total	1991 Total
	Liquid/Air	Air	Liquid				Parabolic Dish/Trough		
	Metallic and Nonmetallic		ICS/Thermosiphon	Flat-Plate (Pumped)	Evacuated Tube	Concentrator			
Residential	6,018	1	295	508	W	W	0	6,832	6,322
Commercial	158	0	4	41	W	W	0	204	225
Industrial	10	0	2	16	0	0	0	27	13
Utility	0	0	2	16	0	0	0	17	12
Other	0	0	(s)	3	0	0	2	6	2
Total	6,187	1	303	584	W	W	2	7,086	6,574

(s) = Less than 500 square feet. ICS = Integral Collector Storage.

W = Data withheld to avoid disclosure.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 13. Shipments of Solar Thermal Collectors by Destination, 1991 and 1992
(Square Feet)

Destination	Shipments		Destination	Shipments	
	1992	1991		1992	1991
Alabama	1,878	31,327	Nebraska	1,749	1,214
Alaska	0	0	Nevada	78,417	26,436
Arizona	209,731	168,164	<u>New Hampshire</u>	1,956	841
Arkansas	2,029	1,282	New Jersey	67,217	54,847
California	1,777,328	2,177,263	<u>New Mexico</u>	8,944	32,457
Colorado	44,667	43,125	New York	68,266	49,699
Connecticut	11,529	15,175	North Carolina	5,609	2,937
Delaware	0	0	<u>North Dakota</u>	0	0
District of Columbia	0	25	Ohio	11,529	2,094
Florida	3,805,357	2,754,760	<u>Oklahoma</u>	92	2,038
Georgia	27,849	31,282	<u>Oregon</u>	82,425	124,607
Hawaii	169,746	240,109	Pennsylvania	29,309	24,374
Idaho	93	10	Puerto Rico	202,589	207,966
Illinois	21,309	3,701	Rhode Island	4,864	12,062
<u>Indiana</u>	9,780	1,546	South Carolina	1,951	1,700
<u>Iowa</u>	126	480	<u>South Dakota</u>	0	0
Kansas	1,905	0	Tennessee	1,749	1,614
Kentucky	0	1,512	Texas	18,837	147,171
Louisiana	1,749	16,207	<u>Utah</u>	47	0
Maine	2,570	16,234	Vermont	1,949	227
Maryland	11,543	1,291	Virgin Islands (U.S.)	7,435	9
Massachusetts	12,098	9,918	Virginia	3,378	2,859
Michigan	47	1,490	Washington	30,413	176
Minnesota	9,087	12,644	West Virginia	161	145
Mississippi	0	1,207	Wisconsin	18,867	15,043
Missouri	1,749	1,214	Wyoming	0	0
Montana	0	1,476			
Shipments to United States/Territories				6,769,923	6,241,960
Exports				315,773	331,997
Total Shipments				7,085,696	6,573,937

Notes: States shown in bold print sponsored incentives for solar thermal collector purchases during 1991 (Solar Energy Industries Association, *Solar Industry Journal*, First Quarter 1992, pp. 16-21). Underlined States sponsored incentives during 1992 (Solar Energy Industries Association, *Solar Industry Journal*, First Quarter 1993, pp. 21-28).

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 14. The Top Five Destinations of Shipments, 1991 and 1992

State or Territory	1992 Shipments			1991 Shipments		
	Thousand Square Feet	Percent of U.S. Total	Rank	Thousand Square Feet	Percent of U.S. Total	Rank
Florida	3,805	56	1	2,755	44	1
California	1,777	26	2	2,177	35	2
Arizona	210	3	3	168	3	5
Puerto Rico	203	3	4	208	3	4
Hawaii	170	3	5	240	4	3
Top Five Total	6,165	91		5,548	89	

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 15. Distribution of Solar Thermal Collector Exports by Continent, 1992
(Percent of Total Exports)

Continent	Percent of Exports
Africa	3.2
Asia	30.8
Europe	14.2
North America	50.6
South America	1.3
Total	100.0

Note: Totals may not equal sum of components due to independent rounding.

Source: Prepared by staff of the Survey Management Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, based on data submitted on Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 16. Distribution of Solar Thermal Collector Exports by Country Within Continent, 1992

Continent	Country	Percent of Exports
Africa	Egypt	3.2
Asia	Saudi Arabia	2.0
	Taiwan	25.0
	Other Asia/Pacific Rim	3.7
Europe	England	4.0
	Germany	4.2
	Other Europe	5.9
North America	Bahamas	5.8
	Canada	6.4
	Costa Rica	4.0
	Guatemala	4.5
	Mexico	9.5
	Other Caribbean/Central America	20.3
South America	Ecuador	0.6
	Other South America	0.6
Total		100.0

Notes: Other represents shipments to countries not disaggregated by companies on Form CE-63A and may include shipments to enumerated countries. Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 17. Complete Solar Thermal Collector Systems Shipped, 1990-1992

	1992	1991	1990
Complete Collector Systems Shipped ^a	15,946	14,780	12,131
System Shipments (thousand square feet)	2,763	2,220	6,561
System Shipments (percent of total shipments)	39	34	58
Number of Companies	35	34	31
Value of Systems (thousand dollars)	19,390	19,451	25,834

^aA complete system is a unit with a collector and all the necessary functional components, except for installation materials.

Source: 1990-1992—Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

2. Photovoltaic Cell and Module Manufacturing Activities

This chapter presents information on the U.S. photovoltaic cell and module manufacturing industry in 1992. It covers the status of the industry, photovoltaic cell and module shipments (expressed in peak watts), manufacturing origins, destinations, imports, exports, cell and module types, values and prices, and uses and markets. Photovoltaic shipments data in this chapter include both cells and modules manufactured by U.S. companies that were shipped for domestic use and for export and also imported cells and modules.

A photovoltaic module is an integrated array of photovoltaic cells assembled into a panel. Photovoltaic cells are the unencapsulated semiconductor components of the module. The photovoltaic cells convert solar energy to electricity. Cells and modules manufactured and shipped for space and satellite applications are not included in this report.

Industry Status

Photovoltaic cell and module shipments totaled 15.6 peak megawatts in 1992 (Table 18). These shipments were reported by 21 companies. Seven companies expect to introduce new crystalline-silicon module products, and ten companies reported plans to introduce new thin-film products to the industry during 1993. Two companies reported plans to produce new photovoltaic concentrator products and four plan new non-module system components during 1993 (Table 19).

Employment in photovoltaic-related activities totaled 1,463 person-years in 1992 (Table 20), a decrease of 125 person-years from the 1991 level of employment. The average employment per company was 70 person-years in 1992, compared with 69 person-years in 1991. Of the 21 companies that reported shipments in 1992, 43 percent reported employment levels of more than 10 person-years each.

Table 18. Photovoltaic Cell and Module Companies and Shipments, 1982-1992
(Peak Kilowatts)

Year	Number of Companies	Photovoltaic Cells and Modules		
		Total Shipments	Import Shipments	Export Shipments
1992 ^a	21	15,583	1,602	9,823
1991 ^a	23	14,939	2,059	8,905
1990 ^a	^b 19	^b 13,837	1,398	7,544
1989 ^a	17	12,825	826	7,363
1988 ^a	14	9,676	1,453	5,358
1987 ^a	17	6,850	921	3,821
1986 ^a	17	6,333	678	3,109
1985 ^a	15	5,769	285	1,670
1984	23	9,912	NA	2,153
1983	18	12,620	NA	1,903
1982	19	6,897	NA	NA

^aDoes not include shipments of cells and modules for space/satellite applications.

^bIncludes imputed data for one nonrespondent, which exited the industry during 1990. See Appendix A for imputation method.

NA = Not available.

Note: Total shipments include import and export shipments.

Sources: **1982-1984**—Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." **1985-1992**—Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 19. Companies Expecting to Introduce New Photovoltaic Products in 1993

New Product Type	Number of Companies
Crystalline Silicon	
Single-Crystal Silicon Modules	3
Cast Silicon Modules	3
Ribbon Silicon Modules	1
Thin-Film	
Amorphous Silicon Modules	6
Other	4
Concentrators	2
Non-Module System Components	4

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 20. Employment in the Photovoltaic Manufacturing Industry, 1989-1992

Year	Number of Companies	Number of Person-Years
1992	21	1,463
1991	23	1,588
1990	19	1,622
1989	17	1,645

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Of the 21 companies that reported in 1992, most were engaged in a broad range of photovoltaic-related activities other than manufacturing and/or importing cells or modules. Eighteen of the 21 companies were involved in module or system design, 15 were active in development of module prototypes, and 12 were active in development of photovoltaic system prototypes (Table 21). Fourteen companies were wholesalers, and 9 companies were retailers. Seven companies, five less than in 1991, were installers of photovoltaic cells or modules.

Shipments

Photovoltaic cell and module shipments in 1992 totaled 15.6 peak megawatts, an increase of 4 percent from the 1991 level (Table 18). Module shipments totaled 12.8 peak megawatts and cell shipments totaled 2.8 peak megawatts. Total shipments have increased 170 percent since 1985 (Figure 4). Beginning in 1985, data for

Table 21. Number of Companies Involved in Photovoltaic Related Activities, 1991 and 1992

Type of Activity	Number of Companies	
	1992	1991
Cell Manufacturing	13	11
Module or System Design	18	19
Prototype Module Development	15	16
Prototype Systems Development	12	14
Wholesale Distribution	14	15
Retail Distribution	9	12
Installation	7	12
Non-Collector System Component Manufacture	6	9

Source: Energy Information, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Figure 4. Photovoltaic Cell and Module Shipments, 1985-1992

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

photovoltaic cells and modules for terrestrial use (not space applications) were first reported.

Imports

Import shipments of photovoltaic cell and modules in 1992 totaled 1.6 peak megawatts, or 10 percent of total shipments (Table 18). These shipments were reported by seven companies. The predominant type of photovoltaic import was crystalline silicon. The countries of origin for the imports were Australia, China, Japan, and the United Kingdom. Japan accounted for most of the imported photovoltaic cells and modules.

Distribution

In 1992, photovoltaic cell and module shipments totaling 8.6 peak megawatts (55 percent of total shipments) were sent directly to wholesale distributors (Table 22). Installers and end users received 2.2 peak megawatts (14 percent of total shipments). Photovoltaic cell manufacturers shipped 2.5 peak megawatts to the companies that manufacture (assemble) cells into photovoltaic modules. Under "Other," 1.1 peak megawatts of cells and modules were shipped predominantly to original equipment manufacturers (OEM) in 1992.

Table 22. Distribution of Photovoltaic Cells and Modules, 1991 and 1992

Recipient	Shipments (peak kilowatts)	
	1992	1991
Wholesale Distributors	8,604	8,848
Retail Distributors	592	782
Exporters	591	310
Installers	1,148	1,260
End Users	1,008	1,095
Module Manufacturers	2,511	1,372
Other ^a	1,129	1,273
Total	15,583	14,939

^aOther includes categories not identified by reporting companies.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Cell and Module Types

Photovoltaic shipments are divided into three categories by product type: (1) crystalline silicon cells and modules (includes single-crystal, cast silicon, and ribbon silicon); (2) thin-film cells and modules (made from a number of layers of photosensitive materials such as amorphous silicon); (3) concentrator cells and modules (in which a lens is used to gather and focus a larger area of sunlight onto a smaller area of the cell or module).

Crystalline silicon cells and modules continued to dominate the photovoltaic industry, accounting for 93 percent of total shipments in 1992 (Table 23). In particular, single-crystal silicon shipments totaled 9.1 peak megawatts, an increase of 5 percent compared with corresponding 1991 shipments (Figure 5). Together, cast and ribbon silicon shipments totaled 5.4 peak megawatts, a 3 percent decrease from the corresponding 1991 shipments.

From 1991 to 1992, thin-film shipments increased 49 percent, while from 1990 to 1991, shipments fell 45 percent. The overall trend from 1990 to 1992 was, however, a decline of 19 percent. Thin-film shipments represented 7 percent of total shipments in 1992.

Values and Prices

The total value of photovoltaic cell and module shipments was \$87.1 million in 1992, a slight increase over the 1991 value of \$86.7 million (Table 24). The total value includes charges for advertising and warranties but does not include excise taxes or the cost of freight or transportation for the shipments.

The total value of crystalline silicon (single-crystal, cast, and ribbon) shipments was \$80 million in 1992, a 2-percent decrease compared with the corresponding 1991 value. The value of thin-film shipments in 1992 was \$6.9 million, 49 percent higher than the corresponding 1991 level.

The average price of crystalline silicon modules in 1992 was \$6.10 per peak watt, a small decrease from the price in 1991 (Figure 6). The average price for thin-film modules was \$6.31 per peak watt, 1 percent higher than their 1991 price. For concentrator modules, the average price was \$4.37 per peak watt, 68 percent lower than their 1991 price (Table 24). This decrease is due to increased levels of shipping by a small number of companies and concurrent lower unit costs.

Table 23. Photovoltaic Cell and Module Shipments by Type, 1990-1992

Type	Shipments (peak kilowatts)			Percent of Total Shipments		
	1992	1991	1990	1992	1991	1990
Crystalline Silicon						
Single-Crystal	9,078	8,685	7,486	58	58	54
Cast and Ribbon	5,379	5,520	5,006	35	37	36
Subtotal	14,457	14,205	12,492	93	95	90
Thin-Film Silicon	1,075	723	1,321	7	5	10
Concentrator Silicon	40	12	24	(*)	(*)	(*)
Other	11	0	0	(*)	0	0
Total	15,583	14,939	13,837	100	100	100

*Represents less than 0.5, rounded to zero.

Notes: Data do not include shipments of cells and modules for space/satellite applications. Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Figure 5. Photovoltaic Cell and Module Shipments by Type, 1989-1992

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Uses

The largest application by end use for photovoltaic cells and modules in 1992 was for electricity generation (combined grid-interactive and remote). This represented 35 percent of total shipments (Table 25). Eighty-nine percent of the 5.5 peak megawatts represented by this end use involved crystalline silicon cells and modules. Grid interactive and remote, or stand alone, power generation for general uses include those for grid distribution and general remote uses for residential power and power for mobile homes.

The second largest photovoltaic end use was to power fixed-base communications equipment, such as mountain-top, signal repeater stations. Cells and modules for communications accounted for 3.7 peak megawatts in 1992, 24 percent of total shipments. In 1991, communications was also the second largest photovoltaic end-use application, representing 24 percent of total shipments.

Photovoltaic units to power consumer goods, such as portable computers and radios, toys, watches, and small battery chargers, totalled 2.6 peak megawatts, the third largest application in 1992. End uses related to transportation and water pumping accounted for 1.6 peak megawatts and 0.8 peak megawatts, respectively, in 1992 and involved primarily the use of crystalline silicon cells and modules. Photovoltaic cells and modules for transportation include cells and modules on boats, cars, and recreational vehicles, and those used

Table 24. Value and Average Price of Cells and Modules by Type, 1991 and 1992

Type	1992			1991		
	Value (thousand dollars)	Average Price (dollars per peak watt)		Value (thousand dollars)	Average Price (dollars per peak watt)	
		Modules	Cells		Modules	Cells
Crystalline Silicon						
Single-Crystal	47,621	6.14	3.12	49,235	6.26	3.88
Cast and Ribbon	32,339	6.04	4.23	32,498	5.92	4.36
Subtotal	79,960	6.10	3.16	81,733	6.11	3.91
Thin-Film Silicon	6,851	6.31	10.67	4,599	6.26	17.43
Concentrator Silicon	189	4.37	10.08	390	13.73	46.86
Other	74	6.00	10.00	0	--	--
Total	87,074	6.11	3.21	86,721	6.12	4.08

W = Data withheld to avoid disclosure.

-- = Not Applicable.

Notes: Data do not include shipments of cells and modules for space/satellite applications. Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Figure 6. Average Price of Photovoltaic Modules, 1990-1992

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

for transportation support systems such as signs, illumination, and warning signals.

Original equipment manufacturers accounted for 0.8 peak megawatts in 1992 and 1.3 peak megawatts in 1991. Photovoltaic cells and modules used for health and medical purposes, such as those used for powering refrigerators, medical equipment, and water purifiers, totaled 67 peak kilowatts in 1992, a 10-percent increase from the corresponding level in 1991.

Destination

Domestic

The industrial sector was the largest market for photovoltaic cells and modules in 1992, accounting for 27 percent of total shipments (Table 26). This market involves the use of photovoltaic cells and modules, of which 98 percent were crystalline silicon and 2 percent were thin-film silicon cells and modules in 1992, to produce power for industrial applications including grid and non-grid systems. The industrial sector also represented the largest market for photovoltaic shipments in 1991.

Photovoltaic cells and modules used in grid-connected and remote (non-grid) photovoltaic systems to provide power for the residential sector was the second largest market for photovoltaics in 1992 (27 percent of total shipments). In contrast, in 1991 cells and modules

Table 25. Shipments of Photovoltaic Cells and Modules by End Use and Type, 1991 and 1992
(Peak Kilowatts)

End Use	Crystalline Silicon	Thin-Film Silicon	Concentrator Silicon	Other	1992 Total	1991 Total
Electricity Generation						
Grid Interactive	710	517	0	0	1,227	856
Remote	4,178	24	37	0	4,238	3,594
Communication	3,700	17	0	0	3,717	3,538
Consumer Goods	2,379	181	0	6	2,566	3,312
Transportation	1,470	127	0	5	1,602	1,523
Water Pumping	776	32	1	0	809	729
Cells/Modules to OEM	806	21	0	0	828	1,315
Health	53	14	0	0	67	61
Other	384	142	2	1	530	13
Total	14,457	1,075	40	11	15,583	14,939

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 26. Shipments of Photovoltaic Cells and Modules by Market and Type, 1991 and 1992
(Peak Kilowatts)

Market Sector	Crystalline Silicon	Thin-Film Silicon	Concentrator Silicon	Other	1992 Total	1991 Total
Industrial	4,203	74	2	0	4,279	3,947
Residential	4,069	85	0	0	4,154	3,624
Commercial	2,211	168	1	6	2,386	3,345
Transportation	1,551	116	0	6	1,673	1,555
Utility	1,032	521	0	0	1,553	1,275
Government	1,063	(s)	0	0	1,063	815
Other	329	111	37	0	477	377
Total	14,457	1,075	40	11	15,583	14,939

(s) = Less than 500 peak watts.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

shipped to the residential market represented 24 percent of total shipments.

The commercial market was the third largest photovoltaic market, accounting for 15 percent of total shipments in 1992. These cells and modules were shipped to produce power for commercial establishments such as office buildings, private hospitals and schools (publicly owned hospitals and schools are listed under the government sector), and retail establishments. In contrast, the commercial sector accounted for 22 percent of total shipments in 1991.

Photovoltaic cells and modules for the transportation sector, which were used to produce power on boats, cars, and recreational vehicles and to power transportation support systems, amounted to 1.7 peak megawatts. The transportation sector accounted for 11 percent of total shipments in 1992 compared with 10 percent in 1991.

Shipments to the utility sector, where cells and modules were used to produce power at utility-owned systems including central stations, decentralized systems, and experimental applications, amounted to 1.6 peak

megawatts in 1992, a 22-percent increase from the 1991 level.

Shipments of photovoltaic cells and modules used to produce power for branches of Federal, State, or local governments (including military) totaled 1.1 peak megawatts in 1992. This compares with 0.8 peak megawatts shipped to the government sector in 1991. The "Other" sector (Table 26) consists of 0.5 peak megawatts shipped to foreign governments and for specialty purposes in 1992.

Exports

Export shipments totaled 10 peak megawatts in 1992, an increase of 10 percent from the 1991 level (Table 18). Generally, exports have increased at about the same pace as total shipments because of the continued search for new photovoltaic markets outside the United States (Figure 4). Seventeen of the 21 reporting companies exported photovoltaic cells and modules, and exports accounted for 63 percent of total photovoltaic shipments in 1992. The major type of cells and modules exported in 1992 were crystalline silicon (98 percent)(Table 27). Destination of photovoltaic exports by continent is shown in Table 28. Countries named as the destination of exports are listed in Table 29.

Systems

Of the 25 companies reporting shipments of photovoltaic systems in 1992, 7 reported shipments of 232 complete photovoltaic systems (Table 30). A complete photovoltaic system is defined as a power supply unit that satisfies all the power requirements of an application. Such a system is generally made up of one or

more modules, a power conditioning unit to process the electricity into the form needed by the application, wires and other electrical connectors, and sometimes batteries for back-up power supply. Some complex, large-scale photovoltaic systems use concentrators to focus solar rays onto a small photovoltaic cell and tracking systems to track the sun. In this report, installation materials such as the support frame and concrete foundations are not considered part of the system. Cost of systems reported in this document exclude excise taxes and charges for freight, transportation, and installation. Total value of complete systems shipped in 1992 was \$7.4 million. Six percent of all modules shipped were complete systems.

Table 28. Destination of Photovoltaic Cell and Module Exports by Continent, 1992

Continent	Percent of Exports
Africa	0.4
Asia	21.2
Australia	0.1
Europe	47.9
North America	18.8
South America	3.2
Other ^a	8.4
Total	100.0

^aDestination not identified by reporting company on Form CE-63B.

Note: Total may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 27. Photovoltaic Shipments for Export, 1992
(Peak Kilowatts)

	Type				Total
	Crystalline Silicon	Thin-Film Silicon	Concentrator Silicon	Other	
Module	6,986	122	35	3	7,146
Cell	2,676	0	(s)	0	2,676
Total	9,662	122	35	3	9,823

(s) = Less than 500 peak watts.

Note: Total may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 29. Destination of Photovoltaic Cell and Module Exports by Countries Receiving Exports, 1992

Country	Peak Kilowatts	Percent of Exports
Argentina	69	0.7
Australia	12	0.1
Bolivia	65	0.7
Brazil	2	(*)
Canada	570	5.8
Chile	2	(*)
China	11	0.1
Colombia	7	0.1
Dominican Republic	3	(*)
England	10	0.1
France	94	1.0
Germany	3,763	38.3
Hong Kong	141	1.4
Hungary	3	(*)
India	3	(*)
Indonesia	169	1.7
Israel	32	0.3
Italy	230	2.3
Japan	1,305	13.3
Malaysia	160	1.6
Mexico	1,244	12.7
Netherlands	170	1.7
Nigeria	1	(*)
Norway	169	1.7
Pakistan	(s)	(*)
Panama	25	0.3
Philippines	4	(*)
Portugal	32	0.3
Senegal	(s)	(*)
Singapore	197	2.0
South Africa	38	0.4
Spain	10	0.1
Swaziland	(s)	(*)
Sweden	39	0.4
Switzerland	181	1.8
Taiwan	57	0.6
Thailand	3	(*)
United Kingdom	3	(*)
Venezuela	101	1.0
Zaire	(s)	(*)
Zambia	(s)	(*)
Zimbabwe	4	(*)
Unspecified	892	8.4
Total	9,823	100.0

(*) Represents less than 0.05 percent.

(s) Less than 500 peak watts.

Note: Total may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 30. Shipments of Complete Photovoltaic Module Systems, 1990-1992

Category	1992	1991	1990
Complete Photovoltaic Systems Shipped (units)	232	795	647
Modules in Complete Systems (peak kilowatts)	781	89	409
Modules in Systems as Percent of Total Module Shipments	6	1	3
Value of Complete Systems (thousand dollars)	7,409	5,625	7,766

Source: Energy Information Administration, Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

A traffic-warning light near Baltimore, Maryland, powered by a 40-peak-watt crystalline silicon photovoltaic module.

Appendix A

Survey Methodology

Appendix A

Survey Methodology

Survey Design

The Energy Information Administration (EIA) conducts the "Annual Solar Thermal Collector Manufacturers Survey" (Form CE-63A), and the "Annual Photovoltaic Module/Cell Manufacturers Survey" (Form CE-63B). Appendix B contains a copy of the survey forms. Forms CE-63A/B are used to collect data from all U.S.-based manufacturers and importers of solar collectors. The surveys cover a 12-month period, from January through December of each year.

Respondents to the surveys are required to report data on (1) manufacturing activities, employment, and plans; and (2) total shipments, including imports and exports, type of collectors, shipment value, and shipment origin and destination. Respondents are requested to report their shipments of solar thermal collectors in terms of square feet and shipments of photovoltaic cells and modules in terms of electrical capacity, expressed in peak kilowatts.

The data collected on Forms CE-63A/B are subject to various sources of error. These sources are: (1) coverage (the list of respondents may not be complete or, on the other hand, there may be double counting); (2) nonresponse (all that are surveyed may not respond or may not provide all information requested); (3) respondents (respondents may commit errors in reporting the data); (4) processing (the data collection agency may omit or incorrectly transcribe a submission); (5) concept (the data collection elements may not measure the items they were intended to measure); and (6) adjustments (errors may be made in estimating values for missing data). Because both of the surveys are census surveys, the estimates shown in this report are not subject to sampling error.³ Although it is not possible to present estimates of nonsampling error, precautionary steps were taken at each stage of the survey design to minimize the possible occurrence of these errors.

³Sampling error is a measure of the variation that occurs by chance because a sample rather than a complete enumeration of units is surveyed.

Survey Universe and Frame

The universe of the CE-63A/B respondents is a census of those U.S.-based companies involved in manufacturing and/or importing solar collectors. Care has been taken to establish the survey frames accurately. The frames of potential respondents are compiled from previous surveys and from information in the public domain. However, because the solar collector industry is subject to sporadic entry and exit of manufacturers and importers, the frame could possibly exclude some small companies that recently entered or reentered the industry.

The 1991 survey frames were updated in late 1992. The 1990 survey frames were updated in late 1991 and again in early 1992. Based on results from updates of the survey frames, data for 1990 (published in *Solar Collector Manufacturing Activity 1990*) were revised in the report, *Solar Collector Manufacturing Activity 1991*.

Survey Procedures

The survey forms were sent out via first class mail to ensure their receipt only by the proper respondent organization. If the U.S. Postal Service was unable to deliver a survey form, the corrected address was obtained where possible. In a few instances, businesses that reported in earlier surveys were no longer operating and therefore were eliminated from the survey frames. All known companies currently conducting business in the U.S. solar collector industry were contacted before and during this survey.

Approximately half of the respondents replied to the form within the specified initial deadlines. Those that did not were mailed another form specifying a new deadline. Those that had not responded by the second deadline were telephoned to encourage submission of

the forms, and those calls resulted in the submission of most of the remaining forms. During the second round of calls, data were taken over the telephone whenever possible. Data received over the phone were entered on a blank survey form. Followup procedures were carried out to reduce the nonresponse rate and possible resulting bias.

Data Editing, Analysis, and Processing

Responses to the surveys were first edited manually to verify the accuracy of the reporting and to ensure reliability of the data. All individual company responses were also compared with the data reported in previous surveys. Wherever manual editing procedures indicated discrepancies or omissions, telephone calls were made to confirm or clarify the data. Data from manually edited forms were then entered into a computer and edited a second time via an automated procedure. After the second edit, a copy of each entry and tabulated computations were reviewed by an analyst familiar with the survey and with the solar collector industry and its companies.

Response Rates

The response rate for both surveys (Forms CE-63A/B) was 100 percent. The status of companies that were mailed CE-63A survey forms for the 1992 survey is shown in Table A1. The 1992 survey responses to surveys sent to 67 potential solar thermal collector companies resulted in the following performance statistics:

- Active companies: Forty-five (45) companies are known to have shipped solar thermal collectors during 1992.
- Inactive: Eighteen (18) companies on the mailing list had no shipments in 1992 but were kept on the list because they may have shipments in future years.
- Out of business: Three (3) of the companies were reported to be out of the solar thermal business during 1992, with no plans to reenter the business in a future year.
- Out of scope: One (1) company reported that it was not involved in solar thermal collector manufacturing or importing solar thermal collectors.

Table A1. Status of 1992 Survey Respondents

Status	Number of Companies	
	Solar Thermal (Form CE-63A)	Photovoltaic (Form CE-63B)
Active	45	21
Inactive	18	18
Out of Business	3	2
Out of Scope	1	6
Total	67	47

Sources: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey," and Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

The status of companies that were mailed CE-63B survey forms for the 1992 survey is shown in Table A1. The 1992 survey responses to surveys sent to 47 potential photovoltaic cell and module companies resulted in the following performance statistics:

- Active companies: Twenty-one (21) companies are known to have shipped photovoltaic cells or modules during 1992.
- Inactive: Eighteen (18) companies on the mailing list had no shipments in 1992 but were kept on the list because they may have shipments in future years.
- Out of business: Two (2) companies were reported to have exited the photovoltaic cell and module business during 1992, with no plans to reenter the business in the future.
- Out of scope: Six (6) companies reported that they were not involved in photovoltaic cell and module manufacturing or importing cells and modules.

Incomplete or Missing Data and Imputation

During the 1990 Form CE-63B survey period, one photovoltaic manufacturer was known to have shipped photovoltaic cells and modules during the first half of 1990. This photovoltaic company had gone out of business in the second half of 1990, and no data were acquired. For this company, one-half of the shipments reported for 1989 was used as the estimate of 1990 shipments.

During 1986 the solar thermal collector manufacturing industry experienced a substantial slowdown in shipments as a result of the expiration of the solar tax credit at the end of 1985 and the reduction in energy prices. Reported shipments declined from 16.4 million square feet in 1984 to 4.9 million square feet in 1986.⁴ Many of the 1986 shipments probably occurred during the first quarter, as customers took delivery of materials purchased in late 1985 when solar tax credits were still available. The number of companies reporting and their reported shipments for the years 1984 through 1986 are presented in Table A2.

Table A2. Number of Reporting Companies and Shipments, 1984, 1985, and 1986

Item	1984	1985 ^a	1986
Number of Companies	224	116	97
Shipments (million square feet) . .	16.4	11.1	4.9

^aIncomplete data.

Sources: **1984**—Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." **1985-1986**—Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Although reported shipments for 1985 were only 68 percent of those reported in 1984, it is likely that actual shipments were higher in 1985, which was believed to be a banner year because the energy tax credit expired at the end of the year. The number of companies reporting and, therefore, the reported shipments may

Table A4. Imputed Solar Thermal Collector Shipments, 1980-1983
(Thousand Square Feet)

Year	Number of Nonrespondents	Imputed Shipments		
		Total ^a	Low-Temperature ^b	Medium-Temperature ^b
1983	21	1,624	1,327	297
1982	9	249	106	143
1981	79	1,771	338	1,433
1980	43	1,631	934	697

^aImputed shipments included in total shipments.

^bImputed shipments included in low-temperature and medium-temperature shipments.

Source: Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey."

⁴The 1984 and 1986 shipment data stated here are the original survey data. These were revised by the Energy Information Administration (EIA) in *Solar Collector Manufacturing Activity 1989*, DOE/EIA-0174(89) (Washington DC, March 1991). The revised data shipments for 1984 are 17.2 million square feet, and 9.4 million square feet for 1986. The revised data include shipments of parabolic dish/trough collectors to independent power producers to generate electricity for the electric grid. For the purposes of this analysis the original data are provided.

have been low because many of the companies had gone out of business, and could not be located to collect the 1985 data when the data collection forms were mailed out more than a year later in early 1987. Shipment data for 80 companies that were in business all three years are presented in Table A3.

Table A3. Shipments of Companies Reporting in 1984, 1985, and 1986

Item	1984	1985 ^a	1986
Number of Companies	80	80	80
Shipments (million square feet) . .	8.7	9.9	4.6

^aIncomplete data.

Sources: **1984**—Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." **1985-1986**—Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

For the 80 companies that were in business all three of the years, 1984 through 1986, shipments increased 14 percent in 1985 but decreased 54 percent in 1986. Although not conclusive, this is an indication that if all shipments for all companies in business in 1985 were reported, there could have been a substantial increase from 1984 to 1985.

During the 1980 through 1983 survey periods for solar thermal collectors, imputed shipment data for non-respondents were included (Tables 1 and 9). The imputed data are presented in Table A4.

Data Revisions

The Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, has adopted the following policy for review and correction (revision) of data it collects and publishes. The policy covers revisions to prior published data. This new policy is initially implemented with the publication of the *Solar Collector Manufacturing Activity 1992*.

1. Annual survey data are published either as *preliminary* or *final* when they first appear in a data report. Data released as *preliminary* will be identified as such. When necessary, preliminary data will be revised and declared to be *final* at the next publication of that data.
2. Monthly and quarterly survey data are published initially as *preliminary* data. They will be revised only after the completion of the data collection cycle for the full 12-month survey period. Revisions will not be made to monthly or quarterly data prior to this time.
3. The magnitude of historical data revisions experienced will be included in each data report to inform the reader about the accuracy of the data presented.
4. Revisions to data published as *final* will be made only in the event that newly available information would result in a change to published data of greater than one percent difference at the national

level. Revisions for changes of lesser magnitudes will be made at the discretion of the Office Director.

All data from Forms CE63/A and CE-63/B are published as final data. All revised data are indicated by an "R" in front of each revised data cell. No 1991 data were revised in this report.

Nondisclosure of Data

To protect the confidentiality of individual respondents' data, a policy was implemented to ensure that the reporting of survey data in this publication would not associate those data with a particular company. This is in compliance with EIA Standard No. 88-05-06, "Non-disclosure of Company Identifiable Data in Aggregate Cells." In tables where the nonzero value of a cell is composed of data from fewer than three companies or if a single company dominates a table-cell value so that the publication of the value would lead to identification of a company's data, then the EIA classifies the cell value as "sensitive," and the cell value is withheld ("W") from publication. Within a table with a sensitive cell value, selected values in other cells of the table are also withheld, as necessary, so that the sensitive cell value cannot be computed using the values in published cells.

A sensitive table-cell value can be reported, if permission is first obtained from each company (whose data contribute to the sensitivity) to publish the value. This is the only exception to the application of EIA Standard No. 88-05-06 in this report.

This 7.5-kilowatt dish-engine system developed and manufactured by Cummins Power Generation, Inc., of Columbus, Indiana, provides power for water pumping in Abilene, Texas.

Appendix B

CE-63A/B Survey Forms and Instructions

Form CE-63A
U.S. DEPARTMENT OF ENERGY
Energy Information Administration
ANNUAL SOLAR THERMAL COLLECTOR MANUFACTURERS SURVEY

This report is mandatory under FEA Act of 1974 (Public Law 93-275) and the Department of Energy Organization Act (Public Law 95-91). Provisions regarding sanctions are described in Part V, page 1 of the instructions. For the provisions concerning the confidentiality of information submitted on this form, see Part VI of the instructions. Public reporting burden for this collection of information is estimated to average 3 hours per response including the time reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Energy Information Administration, Office of Statistical Standards, EI-73, 1000 Independence Ave., SW, Washington, D.C. 20585, and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, D.C. 20503.

The reporting period for this survey is the calendar year 19____

For definitions and instructions, please refer to the General Information and Instructions section of this form.

1.0 IDENTIFICATION DATA

1.1 Respondent Identification

Complete (a) through (d) only if label is incorrect

(a) Company Name: _____

(b) Street Address: _____

(c) City: _____

(d) State and Zip Code: _____

1.2 Provide the name, title, and telephone number of a person in your company to whom questions may be addressed regarding this submission.

(a) Name: _____

(c) Telephone: _____

Area Code Number

(b) Title: _____

2.0 MANUFACTURING STATUS (Please refer to the "definition" section in the instructions for key words.)

2.1 During the current reporting period, did your company:

(Mark as appropriate)

- (a) Manufacture and ship solar thermal collectors?
(b) Cease manufacturing but continue to ship solar thermal collectors?
(c) Import and ship solar thermal collectors?
(d) Manufacture and export solar thermal collectors?

☐ Yes	☐ No
☐ Yes	☐ No
☐ Yes	☐ No
☐ Yes	☐ No

2.2 If you answered "No" to all parts of question 2.1, do you plan to manufacture, import, export, and ship solar thermal collectors in the future? If yes, when? _____(year)

☐ Yes ☐ No

Note: If you answered "Yes" to any part of question 2.1, please complete the remainder of this form.

If you answered "No" to all parts of question 2.1, please complete question 8.0 and return this form in the enclosed envelope or to the address specified in the instructions.

3.0 MANUFACTURER AND MARKETING DATA

3.1 Mark the appropriate box or boxes to indicate all the solar-related activities in which your company was engaged during the survey year. Mark only those that apply to your solar activities.

- (a) ☐ Collector or system design
(b) ☐ Prototype collector development
(c) ☐ Prototype systems development
(d) ☐ Wholesale distribution
(e) ☐ Retail distribution
(f) ☐ Installation
(g) ☐ Manufacture of system-components other than those used for collector assembly
(h) ☐ Other (describe) _____

3.2 If you are planning to introduce a new solar-related product in the next calendar year, please check the appropriate box.

- (a) ☐ Low-Temperature Collector
(b) ☐ Medium-Temperature Collector
(c) ☐ High-Temperature Collector
(d) ☐ Noncollector Solar System Components
(e) ☐ Other (describe) _____

3.3 Please enter the number of person-years expended in your company in solar-related activities during the survey year. (For clarification of "person year," see the instructions) _____person years.

3.4 What percentage of your company's total sales volume do solar-related activities compose?

- (a) ☐ 90 - 100%
(b) ☐ 50 - 89%
(c) ☐ 10 - 49%
(d) ☐ Less than 10%

Company Name: _____ Reporting Period (Calendar year 19__)

4.0 SOLAR THERMAL COLLECTOR-DATA. For each type of collector manufactured or imported, and shipped, enter the data for this reporting period.

ITEM	COLLECTOR TYPE										
	Low Temperature (Liquid and Air)	Air	Medium Temperature				High Temperature	Other (Specify)	Total		
			Metallic and Nonmetallic	All Medium Temperature	Liquid						
					Integral Collector Storage/Thermosiphon	Flat Plate (pumped)				Concentrator	Evacuated Tube
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)			
4.1 Total Collector Shipments (square feet)											
4.2 Total Value of Collector Shipments in 4.1 (dollars)											
4.3 Market Sector (square feet)											
(1) Residential											
(2) Commercial											
(3) Industrial											
(4) Utility											
(5) Other (describe)											
(6) Total market sector*											
4.4 End Use (square feet)											
(1) Pool heating											
(2) Hot water											
(3) Space heating											
(4) Combined space and water heating											
(5) Space cooling											
(6) Process heating											
(7) Electricity generation											
(8) Other (describe)											
(9) Total end use*											
4.5 Imports (square feet of total in 4.1)											
4.6 Exports (square feet of total in 4.1)											
4.7 List country(ies) of Origin of Imports in 4.5											
4.8 List Country(ies) of Destination for Exports with Percent of Exports in 4.6											
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)		
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)		
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)		

*Should equal to shipments in Question 4.1.

4.9 Enter the square footage of collectors from question 4.1(i) that were shipped to

	Square feet (From 4.1(i))
(a) Exporters	_____
(b) Wholesale distributors	_____
(c) Retail Distributors	_____
(d) Installers	_____
(e) End-Users	_____
(f) Other (describe)	_____
TOTAL	_____

5.0 SYSTEMS DATA

- 5.1 Of the total collector shipments reported in question 4.1(i), how many complete systems were shipped _____ (number of systems)?
- 5.2 Of the collector shipments reported in question 4.1(i), enter the square footage that was sold as part of complete systems _____ (square feet).
- 5.3 What was the value of complete systems shipped in question 5.1 _____ (dollars)?

6.0 GEOGRAPHIC DATA

6.1 Report the percentage (%) of your company's collectors manufactured in the state listed below under Code 01-53. If some collectors were imported from another country, please indicate the percentage under Code 00.

State Code	% Collectors Imported or Manufactured in the State	State Code	% Collectors Imported or Manufactured in the State	State Code	% Collectors Imported or Manufactured in the State
00	☐ Imported _____	18	☐ Kentucky _____	36	☐ Ohio _____
01	☐ Alabama _____	19	☐ Louisiana _____	37	☐ Oklahoma _____
02	☐ Alaska _____	20	☐ Maine _____	38	☐ Oregon _____
03	☐ Arizona _____	21	☐ Maryland _____	39	☐ Pennsylvania _____
04	☐ Arkansas _____	22	☐ Massachusetts _____	40	☐ Puerto Rico _____
05	☐ California _____	23	☐ Michigan _____	41	☐ Rhode Island _____
06	☐ Colorado _____	24	☐ Minnesota _____	42	☐ South Carolina _____
07	☐ Connecticut _____	25	☐ Mississippi _____	43	☐ South Dakota _____
08	☐ Delaware _____	26	☐ Missouri _____	44	☐ Tennessee _____
09	☐ D.C. _____	27	☐ Montana _____	45	☐ Texas _____
10	☐ Florida _____	28	☐ Nebraska _____	46	☐ Utah _____
11	☐ Georgia _____	29	☐ Nevada _____	47	☐ Vermont _____
12	☐ Hawaii _____	30	☐ New Hampshire _____	48	☐ Virgin Islands _____
13	☐ Idaho _____	31	☐ New Jersey _____	49	☐ Virginia _____
14	☐ Illinois _____	32	☐ New Mexico _____	50	☐ Washington _____
15	☐ Indiana _____	33	☐ New York _____	51	☐ West Virginia _____
16	☐ Iowa _____	34	☐ North Carolina _____	52	☐ Wisconsin _____
17	☐ Kansas _____	35	☐ North Dakota _____	53	☐ Wyoming _____

Total Percentage _____ % (should amount to 100%)

6.2 Report the percentage (%) of your company's collectors likely to have been shipped to the state listed below under Code 01-53, this includes shipments to the state of manufacture. If some collectors were exported, please indicate the percentage under Code 00.

State Code	% Collectors Exported or Shipped to the State	State Code	% Collectors Exported or Shipped to the State	State Code	% Collectors Exported or Shipped to the State
00	☐ Exported _____	18	☐ Kentucky _____	36	☐ Ohio _____
01	☐ Alabama _____	19	☐ Louisiana _____	37	☐ Oklahoma _____
02	☐ Alaska _____	20	☐ Maine _____	38	☐ Oregon _____
03	☐ Arizona _____	21	☐ Maryland _____	39	☐ Pennsylvania _____
04	☐ Arkansas _____	22	☐ Massachusetts _____	40	☐ Puerto Rico _____
05	☐ California _____	23	☐ Michigan _____	41	☐ Rhode Island _____
06	☐ Colorado _____	24	☐ Minnesota _____	42	☐ South Carolina _____
07	☐ Connecticut _____	25	☐ Mississippi _____	43	☐ South Dakota _____
08	☐ Delaware _____	26	☐ Missouri _____	44	☐ Tennessee _____
09	☐ D.C. _____	27	☐ Montana _____	45	☐ Texas _____
10	☐ Florida _____	28	☐ Nebraska _____	46	☐ Utah _____
11	☐ Georgia _____	29	☐ Nevada _____	47	☐ Vermont _____
12	☐ Hawaii _____	30	☐ New Hampshire _____	48	☐ Virgin Islands _____
13	☐ Idaho _____	31	☐ New Jersey _____	49	☐ Virginia _____
14	☐ Illinois _____	32	☐ New Mexico _____	50	☐ Washington _____
15	☐ Indiana _____	33	☐ New York _____	51	☐ West Virginia _____
16	☐ Iowa _____	34	☐ North Carolina _____	52	☐ Wisconsin _____
17	☐ Kansas _____	35	☐ North Dakota _____	53	☐ Wyoming _____

Total Percentage _____ % (should amount to 100%)

7.0 PUBLICATION DATA

7.1 Do you want the name and address of your company to appear in the appendix of the next "Solar Collector Manufacturing Activity" report?

☐ Yes ☐ No

7.2 Do you want to receive a copy of the next "Solar Collector Manufacturing Activity" report?

☐ Yes ☐ No

8.0 CERTIFICATION

I certify that the historical and estimated information provided hereon and appended hereto are true, complete, and accurate to the best of my knowledge, information, and belief.

Name: _____ Title: _____

Signature: _____ Date: _____

Enter any additional remarks here: _____

Title 18 U.S.C. 1001 makes it a crime for any person knowingly and willingly to make to any Agency or Department of the United States any false, fictitious or fraudulent statement or misrepresentation as to any matter within its jurisdiction.

**INSTRUCTIONS FOR
FORM CE-63A, ANNUAL SOLAR THERMAL COLLECTOR MANUFACTURERS SURVEY
GENERAL INFORMATION AND INSTRUCTIONS**

I. Purpose

Form CE-63A is designed to provide the data necessary for the Energy Information Administration (EIA), U.S. Department of Energy (DOE), to carry out its responsibilities for tracking collector shipments in the solar collector manufacturing industry and for providing information concerning the size and status of the industry. The publication *Solar Collector Manufacturing Activity 1992* will contain the results of this survey.

II. Who Should Respond to This Survey

Form CE-63A is to be submitted by companies (1) that manufactured and shipped (including exporting) solar thermal collectors and (2) that imported solar thermal collectors during the survey year. If you are completing this survey form for the first time but were active in the industry during the previous survey year, please photocopy the entire form and provide us with data for the previous year also.

III. Where to Submit Completed Forms

Completed and signed CE-63A forms should be returned to:

*U.S. Department of Energy
Energy Information Administration, BG-094
1000 Independence Ave., SW
Washington, D.C. 20277-7091*

Request for further information and/or additional forms may be mailed to the above address or telephoned to the survey project manager at (202) 254-5565.

IV. When to Submit Completed Forms

Completed CE-63A forms are due on the date specified in the cover letter. The survey year is from January 1 through December 31 each year.

V. Sanctions

The timely submission of Form CE-63A by those required to report is mandatory under Section 13(b) of the Federal Energy Administration Act of 1974 (FEAA) (Public Law 93-275), as amended. Failure to respond may result in a civil penalty of not more than \$2,500 for each violation, or a fine of not more than \$5,000 for each willful violation. The government may bring a civil action to prohibit reporting violations which may result in a temporary restraining order or a preliminary or permanent injunction without bond. In such civil action, the court may also issue mandatory injunctions commanding any person to comply with these reporting requirements.

VI. Provisions Regarding Confidentiality Of Information

The Office of Legal Counsel of the Department of Justice concluded on March 20, 1991, that the Federal Energy Administration Act requires the Energy Information Administration to provide company-specific data to the Department of Justice, or to any other Federal agency when requested for official use, which may include enforcement of Federal law. The information contained on this form may also be made available, upon request, to another component of the Department of Energy (DOE), to any Committee of Congress, the General Accounting Office, or other Congressional agencies authorized by law to receive such information. A court of competent jurisdiction may obtain this information in response to an order.

The information contained on this form will be kept confidential and not disclosed to the public to the extent that it satisfies the criteria for exemption under the Freedom of Information Act (FOIA), 5 U.S.C. §552, the DOE regulations, 10 C.F.R. §1004.11, implementing the FOIA, and the Trade Secrets Act, 18 U.S.C. §1905.

Upon receipt of a request for this information under the FOIA, the DOE shall make a final determination whether the information is exempt from disclosure in accordance with the procedures and criteria provided in the regulations. To assist us in this determination, respondents should demonstrate to the DOE that, for example, their information contains trade secrets or commercial or financial information whose release would be likely to cause substantial harm to their company's competitive position. A letter accompanying the submission that explains (on an element-by-element basis) the reasons why the information would be likely to cause the respondent substantial competitive harm if released to the public would aid in this determination. A new justification does not need to be provided each time information is submitted on the form, if the company has previously submitted a justification for that information and the justification has not changed.

Page 1

SPECIFIC INSTRUCTIONS

<u>Item</u>	<u>Instruction</u>
1.1	(a-d) Make corrections to the company name or address in the spaces provided.
1.2	(a-c) Enter the name, title, and telephone number of a company contact person who may be contacted for additional information regarding this submission.
2.1	(a-d) Mark as appropriate the manufacturing activity conducted by your company during the current reporting period. If you answer "Yes" to any one of (a) through (d) please begin with Item 3.0 and complete the remainder of this form. If you answer "No" to all of (a) through (d) please complete only Items 2.2 and 8.0.
2.2	If you answered "No" to all of Item 2.1, please mark whether your company plans to begin or continue any manufacturing activity and, if so, in what year.
3.1	(a-h) Report only on activities that are solar related.
3.2	(a-e) A new solar-related product is differentiated from a modified existing product if the "new" product is different enough to warrant a new model number and requires retesting or recertification under existing industry standards.
3.3	Enter the total number of person-years expended on solar-related activities during the survey year. (See definition of "Person Year" on page 4.)
3.4	"Solar-related activities" includes all activities listed in Item 3.1.
4.1	Enter the square footage (not the number of collectors), in whole numbers (i.e., no decimals), of solar collectors by type shipped for final consumption or to another organization for resale (including exports and imports) in the appropriate collector type column. Total (column i) should be the total square footage of all collector types in that row.
4.2	Enter the total value received for the total collector shipments in Item 4.1 by type. The value reported should be the total value received for collectors only at your company's net billing price, freight-on-board factory, including charges for cooperative advertising and warranties. Do not include excise taxes, freight, or transportation. Report values to the nearest dollar. Total (column i) should be the total value of all collector types in that row.
4.3	For each appropriate sector, enter the square footage of collector shipments in Item 4.1 by collector type as precisely as possible. The market-sector categories in Item 4.3 are:

<div style="margin-left: 20px;"> Part (1) <i>Residential</i> - Solar applications related to any building used for residential occupancy that has a system for heating or cooling, or both.
 Part (2) <i>Commercial</i> - Solar applications for use in businesses where services (rather than products) are provided, such as wholesale and retail trade or health and educational services.
 Part (3) <i>Industrial</i> - Solar applications for use in businesses where products (rather than services) are provided, such as the manufacture and processing of goods and basic materials.
 Part (4) <i>Utility</i> - Shipments of solar thermal collectors to utilities for use in power generation or for experimental applications (includes gas and electric utilities). Includes central stations, decentralized systems or experimental applications.
 Part (5) <i>Other</i> - Shipments of solar thermal collectors to other sectors such as "Government" (including the military). </div>
<i>Total market sector</i> - Sum market sector quantities and enter a total for each row [4.3(1)-(5)] in column i. Next, sum columns a through i and enter a total in row 4.3(6) for each column. These column totals should equal shipment totals entered under Item 4.1 by column. The total entered for 4.3(6) in column i should equal the total entered for Item 4.1 in column i. |
| 4.4 | For each end use, enter the square footage of collector shipments in Item 4.1 by collector type as precisely as possible. The end-use categories in Item 4.4 are:

<div style="margin-left: 20px;"> Part (1) <i>Pool Heating</i> - Self-explanatory.
 Part (2) <i>Hot Water</i> - Shipments of solar thermal collectors used only for water heating.
 Part (3) <i>Space Heating</i> - Shipments of solar thermal collectors used only for space heating.
 Part (4) <i>Combined space and water heating</i> - Shipments of solar thermal collectors are used in combination for space and water heating.
 Part (5) <i>Space cooling</i> - Shipments of solar thermal collectors used for space cooling (air conditioning) or for space cooling in combination with water and/or space heating.
 Part (6) <i>Process heating</i> - Shipments of solar thermal collectors used for industrial process heating.
 Part (7) <i>Electricity Generation</i> - Shipments of solar thermal collectors such as concentrators, linear fresnel lens, heliostats, parabolic dishes, and parabolic troughs used as steam generators to power electric generators.
 Part (8) <i>Other</i> - Shipments of solar thermal collectors for other uses such as cooking food, water pumping, water purification, desalinization, distilling, etc. </div> |

SPECIFIC INSTRUCTIONS

<u>Item</u>	<u>Instruction</u>
4.4	Total end use - Sum end-use quantities and enter a total for each row (4.4(1)-(8)) in column i. Next, sum columns a through i and enter a total in row 4.4(9) for each column. These column totals should equal shipment totals entered under Item 4.1 by column. The total entered for 4.4(9) in column i should equal the total entered for Item 4.1 in column i.
4.5	Enter the square footage by collector type. This amount represents the portion of total collector shipments entered in Item 4.1 that were imported and shipped by your company.
4.6	Enter the square footage by collector type. This amount represents the portion of total collector shipments entered in Item 4.1 that were manufactured for export and shipped (sold) to another country.
4.7	List the country(ies) from which solar collectors reported in Item 4.5 were imported.
4.8	List the country(ies) to which solar collectors reported in Item 4.6 were exported, and percent of exports in Item 4.6 for each country listed.
4.9	Of the collectors reported in Item 4.1(i), report in square feet, the recipients of solar thermal collectors immediately following manufacturing or warehousing. If recipients overlap (for example, the recipient is both a wholesale distributor and an installer) report the recipients in the higher category (i.e., a is higher than b, b is higher than c, etc.).
5.1	Enter number of complete systems shipped from the total in Item 4.1(i).
5.2	Of the collectors reported in Item 4.1(i), enter the square footage that was sold as complete systems. (Complete system is defined as unit with all the necessary functional components, except for installation materials. These include thermosiphon systems, integral collector storage systems, packaged systems, or system kits.)
5.3	The value reported should be total value received for the complete systems at your company's net billing price, freight-on-board factory, including charges for cooperative advertising and warranties. (It should include the value of associated collectors.) Do not include excise taxes, freight or transportation charges, or installation charges. Report values to the nearest dollar.
6.1	Please identify only the State of final assembly of the collector. Please be certain to provide total percentage calculations.
6.2	Refers to collector shipments only. Indicate the last State of destination of which you are aware.
7.1	Mark as appropriate.
7.2	Mark as appropriate.
8.0	Self-explanatory.

DEFINITIONS

1. **Air Collector** - A medium-temperature solar thermal collector used predominantly in space-heating application and which utilizes pumped air as the heat-transfer medium.
2. **Concentrator** - A reflective or refractive device that focuses solar rays onto an area smaller than the reflective or refractive surface, resulting in higher intensity solar rays at the point of focus.
3. **Evacuated-Tube Collector** - A solar thermal collector in which the collector fluid flows through an absorber tube that is contained inside an evacuated glass cylinder.
4. **Export (solar)** - A shipment of solar thermal collectors and/or photovoltaic devices sent from the United States and any of its territories to a foreign country.
5. **Flat Plate (pumped)** - A medium-temperature solar thermal collector, typically made with a metal frame, glazing, absorbers (usually metal), and insulation, that uses pumped liquid as the heat-transfer medium; predominantly used in water-heating applications.
6. **High-Temperature Collectors** - A solar thermal collector that generally operates at temperatures above 180 degrees Fahrenheit.
7. **Import (solar)** - A shipment of solar thermal collectors and/or photovoltaic devices into the United States and any of its territories from foreign countries.
8. **Integral Collector Storage (ICS)** - A solar thermal collector in which incident solar radiation is absorbed directly by the storage medium.
9. **Liquid Collector** - A medium-temperature solar thermal collector used predominantly in water heating, utilizing pumped liquid as the heat-transfer medium.
10. **Low-Temperature Collectors** - A solar thermal collector that generally operates at temperatures below 100 degrees Fahrenheit.
11. **Medium-Temperature Collectors** - A solar thermal collector that generally operates in the temperature range of 140 degrees Fahrenheit to 180 degrees Fahrenheit but can also operate at a temperature as low as 100 degrees Fahrenheit.
12. **Parabolic Dish** - A high temperature (above 180 degrees Fahrenheit) solar thermal concentrator, generally bowl-shaped, with the capacity for tracking the sun using two axes of rotation.
13. **Parabolic Trough** - A high temperature (above 180 degrees Fahrenheit) solar thermal concentrator with the capacity for tracking the sun using one axis of rotation.
14. **Person Year** - One whole year, or fraction thereof, worked by an employee. It is expressed as a quotient (to two decimal places) of the time units worked during a year (hours, weeks, months) divided by the like total time units in a year. For example: 80 hours worked is 0.04 (rounded) of a person year; 3 weeks worked is 0.06 (rounded) of a person year; 12 months worked is 1.0 person year.
15. **Solar Thermal Collector** - A device designed to receive solar radiation and convert it into thermal energy. Normally, a solar thermal collector includes a frame, glazing, and an absorber, together with appropriate insulation. The heat collected by the solar thermal collector may be used immediately or stored for later use.
16. **Thermosiphon System** - A solar collector system for water heating in which circulation of the collection fluid through the storage loop is provided solely by the temperature and density difference between the hot and cold fluids.

Form CE-63B
U.S. DEPARTMENT OF ENERGY
Energy Information Administration
ANNUAL PHOTOVOLTAIC MODULE/CELL MANUFACTURERS SURVEY

This report is mandatory under FEA Act of 1974 (Public Law 93-275) and the Department of Energy Organization Act (Public Law 95-91). Failure to comply may result in criminal fines, civil penalties and other sanctions as provided by law. For the provisions concerning the confidentiality of information submitted on this form, see Part VI of the instructions. *Public reporting burden for this collection of information is estimated to average 3 hours per response* including the time reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Energy Information Administration, Office of Statistical Standards, EI-73, Mail Station 1H-023 Forrestal, 1000 Independence Ave., S.W., Washington, D.C. 20585, and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, D.C. 20503.

The reporting period for this survey is calendar year 19__

For definitions and instructions, please refer to the General Information and Instructions section of this form.

1.0 IDENTIFICATION DATA

1.1

Complete (a) through (d) only if label is incorrect:

- (a) Company Name: _____
(b) Street Address: _____
(c) City: _____
(d) State and Zip Code: _____

1.2 Provide the name, title, and telephone number of a person in your company to whom questions may be addressed regarding this submission.

- (a) Name: _____ (c) Telephone: _____
Area Code Number
(b) Title: _____

2.0 MANUFACTURING STATUS (Please refer to the "definition" section for key words.)

2.1 During the current reporting period, did your company:

(Mark as appropriate)

- (a) Manufacture and ship photovoltaic modules/cells? ☐ Yes ☐ No
(b) Cease manufacturing but continue to ship photovoltaic modules/cells? ☐ Yes ☐ No
(c) Import and ship photovoltaic modules/cells? ☐ Yes ☐ No
(d) Manufacture and export photovoltaic modules/cells? ☐ Yes ☐ No

2.2 If you answered "No" to all parts of question 2.1, do you plan to manufacture, import, export, and ship photovoltaic modules/cells in the future? If yes, when? _____ (year)

☐ Yes ☐ No

Note: If you answered "Yes" to any part of question 2.1, please complete the remainder of this form.

If you answered "No" to all parts of question 2.1, please complete question 7.0 and return this form in the enclosed envelope or to the address specified in the instructions.

3.0 MANUFACTURER AND MARKETING DATA

3.1 Mark the appropriate box or boxes to indicate all the photovoltaic-related activities in which your company was engaged in during this reporting period. Mark all that apply to your photovoltaic activities only.

- (a) ☐ Cell manufacturing
(b) ☐ Module or system design
(c) ☐ Prototype module development
(d) ☐ Prototype systems development
(e) ☐ Wholesale distribution of modules
(f) ☐ Retail distribution of modules
(g) ☐ Installation
(h) ☐ Manufacture of system-components other than those used for module assembly
(i) ☐ Other (describe): _____

3.2 If you are expecting to introduce new photovoltaic-related products in the next calendar year, please check the appropriate box(es).

- (a) ☐ Single-crystal silicon modules
(b) ☐ Cast silicon modules
(c) ☐ Ribbon silicon modules
(d) ☐ Amorphous silicon modules
(e) ☐ Other thin film
(f) ☐ Other (flat plate) - specify: _____
(g) ☐ Other (concentrator) - specify: _____
(h) ☐ Nonmodule system components - specify: _____

3.3 Please enter the number of full-time-equivalent employees in your company that were engaged in photovoltaic-related activities during this reporting period. (For clarification of "full-time-equivalent," see the instructions.) _____

Page 1

Company Name: _____

440 PHOTOVOLTAIC MODULES AND CELL SHIPMENT DATA For each type of module/cell manufactured or imported, and shipped, enter the data for this reporting period.

4.0 PHOTOVOLTAIC MODULES AND CELL SHIPMENT DATA. For each type of module/cell manufactured or imported, and shipped, enter the data for this reporting period.									
ITEM	MODULE/CELL TYPE								Total
	Crystalline Silicon			Thin Film		Concentrator	Other		
	Single-Crystal (Czochralsky) (a)	Cast (b)	Ribbon (c)	Amorphous Silicon (d)	Other (e)				
4.1 Quantity of Shipments (in kw)									
(1) Total net module shipments									
(2) Total net cell shipments									
Total quantity of shipments									
4.2 Value of Shipments (dollars)									
(1) Value of module shipments									
(2) Value of cell shipments									
Total value of shipments									
4.3 End Use (in kw)									
(1) Health									
(2) Water pumping									
(3) Transportation									
(4) Communication									
(5) Consumer goods (modules)									
(6) Electric generation									
(a) Grid interactive									
(b) Other remote (stand alone)									
(7) Cells to original equipment manufactured (non-PV)									
(8) Other uses: Specify _____									
Total end use*									
4.4 Market Sector									
(1) Government									
(2) Residential									
(3) Commercial									
(4) Industrial									
(5) Utility									
(6) Transportation									
(7) Other sectors: Specify _____									
Total market sector*									
4.5 Imports (in kw)									
(1) Modules									
(2) Cells									
Total Imports									
4.6 Exports (in kw)									
(1) Modules									
(2) Cells									
Total exports									
4.7 List Country(ies) of Origin of Imports In Question 4.5									
4.8 List Country(ies) of Destination for Exports In Question 4.6									

* Should equal to shipments reported in Question 4.1.

4.9 Enter the quantity (in kilowatts) of modules and cells reported in 4.1(1)(h) and 4.1(2)(h) that were shipped to:

	<u>Modules</u> (From 4.1(1)(h))	<u>Cells</u> (From 4.1(2)(h))
(a) Exporters	_____	_____
(b) Module Manufacturers	_____	_____
(c) Wholesale Distributors	_____	_____
(d) Retail Distributors	_____	_____
(e) Installers	_____	_____
(f) End-Users	_____	_____
(g) Other (describe)	_____	_____
TOTAL	_____	_____

5.0 TOTAL SHIPMENT DATA

5.1 Of the total modules shipped in 4.1(1)(h), how many complete systems were shipped _____ (number of systems)?

5.2 Of the modules shipped in 4.1(1)(h), enter the peak kilowatts that were sold as part of complete systems _____ (kilowatts).

5.3 What was the value of complete systems shipped in question 5.1 _____ (dollars)?

6.0 PUBLICATION DATA

6.1 Do you want the name and address of your company to appear in the appendix of the next Solar Collector Manufacturing Activity report? ☐ Yes ☐ No

Do you want to receive a copy of the next Solar Collector Manufacturing Activity report? ☐ Yes ☐ No

7.0 CERTIFICATION

I certify that the information contained and appended is true and accurate to the best of my knowledge.

Name: _____ Title: _____

Signature: _____ Date: _____

Enter any additional remarks here: _____

**INSTRUCTIONS FOR
FORM CE-63B, ANNUAL PHOTOVOLTAIC MODULE/CELL MANUFACTURERS SURVEY****GENERAL INFORMATION AND INSTRUCTIONS****I. Purpose**

Form CE-63B is designed to provide the data necessary for the Energy Information Administration (EIA), U.S. Department of Energy (DOE), to carry out its responsibilities for tracking collector shipments in the solar collector manufacturing industry and for providing information concerning the size and status of the industry. The publication *Solar Collector Manufacturing Activity 1992* will contain the results of this survey.

II. Who Should Respond to This Survey

Form CE-63B is to be submitted by companies that (1) manufactured and shipped (including exporting) photovoltaic cells and modules and (2) that imported photovoltaic cells and modules during the survey year. If you are completing this survey form for the first time but were active in the industry during the previous survey year, please photocopy the entire form and provide us with data for the previous year also.

III. Where to Submit Completed Forms

Completed and signed CE-63B forms should be returned to:

*U.S. Department of Energy
Energy Information Administration, BG-094
1000 Independence Ave., SW
Washington, D.C. 20277-7091*

Request for further information and/or additional forms may be mailed to the above address or telephoned to the survey project manager at (202) 254-5565.

IV. When to Submit Completed Forms

Completed CE-63B forms are due on the date specified in the cover letter. The survey year is from January 1 through December 31 each year.

V. Sanctions

The timely submission of Form CE-63B by those required to report is mandatory under Section 13(b) of the Federal Energy Administration Act of 1974 (FEAA) (Public Law 93-275), as amended. Failure to respond may result in a civil penalty of not more than \$2,500 for each violation, or a fine of not more than \$5,000 for each willful violation. The government may bring a civil action to prohibit reporting violations which may result in a temporary restraining order or a preliminary or permanent injunction without bond. In such civil action, the court may also issue mandatory injunctions commanding any person to comply with these reporting requirements.

VI. Provisions Regarding Confidentiality Of Information

The Office of Legal Counsel of the Department of Justice concluded on March 20, 1991, that the Federal Energy Administration Act requires the Energy Information Administration to provide company-specific data to the Department of Justice, or to any other Federal agency when requested for official use, which may include enforcement of Federal law. The information contained on this form may also be made available, upon request, to another component of the Department of Energy (DOE), to any Committee of Congress, the General Accounting Office, or other Congressional agencies authorized by law to receive such information. A court of competent jurisdiction may obtain this information in response to an order.

The information contained on this form will be kept confidential and not disclosed to the public to the extent that it satisfies the criteria for exemption under the Freedom of Information Act (FOIA), 5 U.S.C. §552, the DOE regulations, 10 C.F.R. §1004.11, implementing the FOIA, and the Trade Secrets Act, 18 U.S.C. §1905.

Upon receipt of a request for this information under the FOIA, the DOE shall make a final determination whether the information is exempt from disclosure in accordance with the procedures and criteria provided in the regulations. To assist us in this determination, respondents should demonstrate to the DOE that, for example, their information contains trade secrets or commercial or financial information whose release would be likely to cause substantial harm to their company's competitive position. A letter accompanying the submission that explains (on an element-by-element basis) the reasons why the information would be likely to cause the respondent substantial competitive harm if released to the public would aid in this determination. A new justification does not need to be provided each time information is submitted on the form, if the company has previously submitted a justification for that information and the justification has not changed.

SPECIFIC INSTRUCTIONS

<u>Item</u>	<u>Instructions</u>
1.1	(a-d) Make corrections to the company name or address in the spaces provided.
1.2	(a-c) Enter the name, title, and telephone number of a company contact person who may be contacted for additional information regarding this submission.
2.1	(a-d) Mark as appropriate the manufacturing activity conducted by your company during the current reporting period. If you answer "Yes" to any one of (a) through (d) please begin with Item 3.0 and complete the remainder of this form. If you answer "No" to all of (a) through (d) please complete only Items 2.2 and 7.0.
2.2	If you answered "No" to all of Item 2.1, please mark whether you company plans to begin or continue any manufacturing activity, and if so, in what year.
3.1	(a-i) Report only on activities that are photovoltaic related.
3.2	(a-h) A new photovoltaic product is differentiated from a modified existing product if the "new" product is different enough to warrant a new model number and requires retesting or recertification under existing industry standards.
3.3	Enter the total number of person-years expended on photovoltaic-related activities during the survey year. (See definition of "Person Year" on page 4.)
4.1	Quantity (in peak kilowatts) of photovoltaic module/cell shipments for terrestrial use only. Photovoltaic modules/cells intended for applications in space programs (satellites, military projects, etc.) are to be excluded.
	Part (1) <i>Total net module shipments</i> - Enter the quantity in peak kilowatts (not the number of modules) of net photovoltaic modules shipped for final consumption or to another organization for resale (including exports and imports) in the appropriate module/cell type column. (Net photovoltaic module is defined on page 4.) When exported, incomplete modules and un-encapsulated cells are also included. Total (column h) should be the total peak kilowatts of all module types in that row.
	Part (2) <i>Total net cell shipments</i> - Enter the quantity in peak kilowatts (not the number of cells) of net photovoltaic cells shipped to end-users or non-photovoltaic original equipment manufacturers (including exports and imports) in the appropriate module/cell type column. (Net photovoltaic cell is defined on page 4.) Photovoltaic cells which are shipped to U.S. based photovoltaic module manufacturers should <u>not</u> be reported. Incomplete cells, such as wafers, should <u>not</u> be reported. Total (column h) should be the total peak kilowatts of all module types in that row.
	<i>Total quantity of shipments</i> - Sum under 4.1(3) the quantities of 4.1(1) and 4.1(2) for all types (columns a through g) and Totals, (column h).
4.2	Value (in dollars) of photovoltaic module/cell shipments in Item 4.1. The value reported should be total value received for modules/cells only at your company's net billing price, freight-on-board factory, including charges for cooperative advertising and warranties. Do not include excise taxes, freight, or transportation. Report values to the nearest dollar.
	Part (1) <i>Value of net module shipments</i> - Enter under 4.2(1) the total value of net photovoltaic modules in Item 4.1(1). Total (column h) should be the total value of all module types in that row.
	Part (2) <i>Value of net cell shipments</i> - Enter under 4.2(2) the total value of net photovoltaic cells in Item 4.1(2). Total (column h) should be the total value of all cell types in that row.
	<i>Total value of shipments</i> - Sum under 4.2(3) the values of 4.2(1) and 4.2(2) for all types (columns a through g) and Totals, (column h).
4.3	For each end use, enter the peak kilowatt quantity of module/cell shipments in Item 4.1(3) by type as precisely as possible. The end-use categories in Item 4.3 are:
	Part (1) <i>Health</i> - Photovoltaic modules/cells used in health/medical applications such as those used for powering medical refrigerators, medical equipment and for water purifications.
	Part (2) <i>Water Pumping</i> - Photovoltaic modules/cells used for pumping water for agricultural, land reclamation, commercial and other similar applications where water pumping is the main use.
	Part (3) <i>Transportation</i> - Photovoltaic modules/cells used on boats, cars, and recreational vehicles; and those used for transportation support systems such as signs, illumination, warning signals, etc.
	Part (4) <i>Communication</i> - Photovoltaic modules/cells employed to power fixed base telecommunications equipment, such as mountain-top repeater stations. Modules/cells issued for space applications are <u>not</u> to be included in this survey.
	Part (5) <i>Consumer goods</i> - Photovoltaic modules/cells used to power products such as portable radios, toys, watches, calculators, small battery chargers, etc. (Please specify on the bases of stabilized full sun rating.)
	Part (6) <i>Electric Generation</i> - Grid interactive and remote or stand alone power generation for general uses, including those for grid distribution and general remote uses like: residential power and power for mobile homes.

SPECIFIC INSTRUCTIONS

Item	Instructions
4.3	Part (7) <i>To original equipment manufacturers (non-PV)</i> - Photovoltaic cells or modules shipped to non-photovoltaic original equipment manufacturers (OEM) that combines the cells into existing or newly developed product lines such as boats, cars, etc. Part (8) <i>Other uses</i> - Shipments of photovoltaic cells and modules for other uses such as cooking food, desalinization, distilling, etc. Total end use - Sum end-use quantities and enter a total for each row [4.3(1)-(8)] in column h. Next, sum columns a through h and enter a total in row 4.3(9) for each column. These column totals should equal shipment totals entered under Item 4.1(3) by column. The total entered for 4.3(9) in column h should equal the total entered for Item 4.1(3) in column h.
4.4	For each appropriate sector, enter the peak kilowatt quantity of module/cell shipments in Item 4.1(3) by type as precisely as possible. The market-sector categories in Item 4.4 are: Part (1) <i>Government</i> - Photovoltaic modules/cells for terrestrial use and employed to produce power for any branch of the U.S. Federal, State, and local government (including the military and including such uses as research, development, and demonstration projects). This excludes foreign government, which should be reported in Item 4.4 Part (7), Other sectors. Part (2) <i>Residential</i> - Photovoltaic modules/cells that are used in distributed, grid connected photovoltaic systems to provide power for residential applications. Part (3) <i>Commercial</i> - Photovoltaic modules/cells employed to produce power for commercial establishments, such as office buildings, private hospitals, private schools, retail establishments, etc. (Publicly owned schools, hospitals, and other institutions should be listed under government.) Part (4) <i>Industrial</i> - Photovoltaic modules employed to produce power for industrial applications. Includes both grid and non-grid connected systems. Part (5) <i>Utility</i> - Photovoltaic modules/cells used to produce power at an utility owned system including central stations, decentralized systems or experimental applications. Part (6) <i>Transportation</i> - Photovoltaic modules/cells used to produce power on boats, cars, and recreational vehicles; and those used to power transportation support systems such as signs, illumination, warning signals, etc. Part (7) <i>Other sectors</i> - Self explanatory. Total market sector - Sum market sector quantities and enter a total for each row [4.4(1)-(7)] in column h. Next, sum columns a through h and enter a total in row 4.4(8) for each column. These column totals should equal shipment totals entered under Item 4.1(3) by column. The total entered for 4.4(8) in column h should equal the total entered for Item 4.1(3) in column h.
4.5	Quantity (in peak kilowatts) of imported photovoltaic modules/cells that represents the portion of photovoltaic shipments entered in Item 4.1 (1) and (2) by module/cell type that were imported and shipped by your company. Part (1) <i>Modules</i> - Enter the peak kilowatts of imported photovoltaic modules by type. This amount represents the portion of total shipments in Item 4.1(1). Total (column h) should be the total peak kilowatts of all imported module types in that row. Part (2) <i>Cells</i> - Enter the peak kilowatts of imported photovoltaic cells by type. This amount represents the portion of total shipments in Item 4.1(2). Total (column h) should be the total peak kilowatts of all imported cell types in that row. Total Imports - Sum under 4.5(3) the quantities of 4.5(1) and 4.5(2) for all types (columns a through g) and Total, (column h).
4.6	Quantity (in peak kilowatts) of exported photovoltaic modules/cells that represents the portion of photovoltaic shipments entered in Item 4.1(1) and (2) by module/cell type that were exported by your company. Part (1) <i>Modules</i> - Enter the peak kilowatts of exported photovoltaic modules by type. This amount represents the portion of total shipments in Item 4.1(1). Total (column h) should be the total peak kilowatts of all exported module types in that row. Part (2) <i>Cells</i> - Enter the peak kilowatts of exported photovoltaic cells by type, including those cells that were shipped to foreign photovoltaic module manufacturers. This amount represents the portion of total shipments in Item 4.1(2). Total (column h) should be the total peak kilowatts of all exported cell types in that row. Total Exports - Sum under 4.6(3) the quantities of 4.6(1) and 4.6(2) for all types (columns a through g) and Total, (column h).
4.7	List the country(ies) from which photovoltaic modules/cells reported in Item 4.5 were imported.
4.8	List the country(ies) to which photovoltaic modules/cells reported in Item 4.6 were exported, and percent of exports in Item 4.6 for each country listed.
4.9	Of the modules/cells reported in Item 4.1 (1) and (2), report in peak kilowatts, the recipients of modules/cells immediately following manufacturing or warehousing. If recipients overlap (for example, the recipient is both a wholesaler distributor and an installer), report the recipients in the higher category (i.e., a is higher than b, b is higher than c, etc.).

SPECIFIC INSTRUCTIONS

Item	Instructions
5.1	Enter the number of complete systems shipped from the total modules in Item 4.1(1) (column h).
5.2	Of the modules reported in Item 4.1(1)(h), enter the peak kilowatts that were sold as complete systems. (Complete system is defined as a unit with all the necessary functional components, except for installation materials.)
5.3	The value reported should be the total value received for the complete systems at your company's net billing price, freight-on-board factory, including charges for cooperative advertising and warranties. (It should include the value of the associated modules.) Do not include excise taxes, freight or transportation charges, or installation charges. Report values to the nearest dollar.
6.1	Mark as appropriate.
7.0	Self-explanatory.

DEFINITIONS

1. **Amorphous Silicon** - An alloy of silica and hydrogen, with an irregular internal atomic arrangement, that can be deposited in thin-film layers (a few micrometers in thickness) by means of a number of deposition methods to produce thin-film photovoltaic cells on glass, metal, or plastic substrates.
2. **Cast Silicon** - Crystalline silicon obtained by pouring pure molten silicon into a vertical mold and adjusting the temperature gradient along the mold volume during cooling to obtain slow, vertically-advancing crystallization of the silicon. The polycrystalline ingot thus formed is composed of large, relatively parallel, interlocking crystals. The cast ingots are sawed into wafers for further fabrication into photovoltaic cells. Cast-silicon wafers and ribbon-silicon sheets fabricated into cells are usually referred to as polycrystalline photovoltaic cells.
3. **Concentrator** - A reflective or refractive device that focuses solar rays onto an area smaller than the reflective or refractive surface, resulting in higher intensity solar rays at the point of focus.
4. **Export (solar)** - A shipment of solar thermal collectors and/or photovoltaic devices sent from the United States and any of its territories to a foreign country.
5. **Import (solar)** - A shipment of solar thermal collectors and/or photovoltaic devices into the United States and any of its territories from foreign countries.
6. **Peak Kilowatt (kWp)** - One thousand peak watts.
7. **Net Photovoltaic Cell Shipment** - The difference between photovoltaic cell shipments and photovoltaic cell purchases.
8. **Net Photovoltaic Module Shipment** - The difference between photovoltaic module shipments and photovoltaic module purchases.
9. **Peak Watt** - A manufacturer's unit indicating the amount of power a photovoltaic cell or module will produce at standard test conditions (normally 1,000 watts per square meter and 25 degrees Celsius).
10. **Person Year** - One whole year, or fraction thereof, worked by an employee. It is expressed as a quotient (to two decimal places) of the time units worked during a year (hours, weeks, months) divided by the like total time units in a year. For example: 80 hours worked is 0.04 (rounded) of a person-year; 3 weeks worked is 0.06 (rounded) of a person-year; 12 months worked is 1.00 person-year.
11. **Photovoltaic Cell** - An electronic device consisting of layers of semiconductor materials fabricated to form a junction (adjacent layers of materials with different electronic characteristics) and electrical contacts, and being capable of converting incident light directly into electricity (direct current).
12. **Photovoltaic Module** - An integrated assembly of interconnected photovoltaic cells designed to deliver a selected level of working voltage and current at its output terminals, packaged for protection against environment degradation, and suited for incorporation in photovoltaic power systems.
13. **Ribbon Silicon** - Sheets of crystalline silicon fabricated by a variety of solidification (crystallization) methods whereby thin silicon sheets are withdrawn from a pool of relatively pure molten silicon. The methods include: edge-defined, film-fed growth (EFG) and dendritic-web growth.
14. **Silicon** - A nonmetallic element with atomic number 14 and valence of 4. It occurs extensively in earth's crust as silica (SiO_2) and silicates (SiO_2 + other elements and/or molecules). As a chemically altered extract, silicon is used in alloys and electronic devices such as photovoltaic cells.
15. **Single Crystal Silicon (Czochralski)** - An extremely pure form of crystalline silicon produced by the Czochralski method of dipping a single crystal seed into a pool of molten silicon under high vacuum conditions and slowly withdrawing a solidifying single crystal boule of silicon. The boule is sawed into thin silicon wafers and fabricated into single-crystal photovoltaic cells.

Appendix C

Respondents to the 1992 Solar Thermal Collector Manufacturers Survey (Form CE-63A)

Solar air-heating system at Ford Motor Company's Chicago Stamping Plant.

Appendix C

Respondents to the 1992 Solar Thermal Collector Manufacturers Survey (Form CE-63A)

Of the companies reporting data on Form CE-63A, 43 gave permission to have their company name and address listed in this publication.

Access Technology Corporation
360 Center Street
Bangor, Maine 04401

American Energy Technologies
P.O. Box 1865
Green Cove Springs, Florida 32043

American Solar Network, Ltd.
5480 Gibbons Drive, Suite H
Carmichael, California 95608

Applied Solar Products
4580 Almaden Expressway
San Jose, California 95118

Aquatherm Industries, Inc.
1985 Rutgers University Blvd.
Lakewood, New Jersey 08701

Astron Technologies
4001 Atlantic Avenue
Raleigh, North Carolina 27604

Bio-Energy Systems, Inc.
P.O. Box 191
48 Canal St.
Ellenville, New York 12428

Caribe Sol De Puerto Rico
Apartado 190
Mayaguez, Puerto Rico 00709

Conserval Systems, Inc.
2211 Main St., Building B
Buffalo, New York 14214

Contemporary Systems, Inc.
Route 12
Walpole, New Hampshire 03608

Cummins Power Generation, Inc.
Box 3005
Columbus, Indiana 47202

Energy Concepts Co.
627 Ridgely Avenue
Annapolis, Maryland 21401

FAFCO, Inc.
2690 Middlefield Road
Redwood City, California 94063

GS Energy Industries, Inc.
108 Jefferson Avenue
Des Moines, Iowa 50314

Haleakala Resources, Inc.
250 Alamaha Place, S-6
Kahului, Hawaii 96732

Heliocol USA, Inc.
927 Fern Street, #200
Altamonte-Springs, Florida 32701

Heliodyne Corporation
4910 Seaport Avenue
Richmond, California 94804

Industrial Solar Technology
5771 West 52nd Avenue
Denver, Colorado 80212

Keenan Solar, Inc.
7000 SW 22nd Ct., 127C
Davie, Florida 33317

Nippon Electric Glass America, Inc.
650 E. Devon Avenue, Suite 110
Itasca, Illinois 60143

Puerto Rico Solar Products
PO Box 702
Moca, Puerto Rico 00716

Radco Products, Inc.
2877 Industrial Parkway
Santa Maria, California 93455

S & L Solar System Co., Inc.
PO Box 1535
Carolina, Puerto Rico 00984

Sage Advance Corporation
P.O. Box 23136
Eugene, Oregon 97402

Sealed Air Corporation
3433 Arden Road
Hayward, California 94545

SEMCO
901 21st, N.W.
Albuquerque, New Mexico 87104

SOLAHART USA
155 Mata Way, Suite 109
San Marcos, California 92069

Solar Alternative, Inc.
PO Box 739
Brattleboro, Vermont 05301

Solar Development, Inc.
3607A Prospect Avenue
Riviera Beach, Florida 33404

Solar Energy & Resources, Inc.
PO Box 2929
Bayamon, Puerto Rico 00960

Solar Living, Inc.
PO Box 12
Netcong, New Jersey 07857

Solar Specialists, Inc.
6825 Mercedes Avenue
Citrus Heights, California 95621

SunEarth, Inc.
4315 Santa Ana Street
Ontario, California 91761

Sun Glow Systems
P.O. Box 18324
Fountain Hills, Arizona 85268

Sun Qest, Inc.
1555 Rankin Avenue
Newton, North Carolina 28658

Sun Ray Solar Heaters
1943-A Friendship Drive
El Cajon, California 92020

Sun Trapper Solar Systems, Inc.
134 West Rhapsody Drive
San Antonio, Texas 78216

Sunwatt Corporation
RFD Box 751
Addison, Maine 04606

Sun Works, Inc.
1001 NW 50th Street
Sunrise, Florida 33351

Thermal Conversion Technology, Inc.
PO Box 3887
Sarasota, Florida 34230

Thermomax USA, Ltd.
1201 Louisiana Avenue
Winter Park, Florida 32789

Universal Solar Products, Inc.
PO Box 364027
San Juan, Puerto Rico 00936

Virginia Solar Components, Inc.
Route 4, Box 87
Rustburg, Virginia 24588

Appendix D

Respondents to the 1992 Photovoltaic Module/Cell Manufacturers Survey (Form CE-63B)

Thin-film photovoltaic modules, being tested for widespread utility use.

Appendix D

Respondents to the 1992 Photovoltaic Module/Cell Manufacturers Survey (Form CE-63B)

Of the companies reporting data on Form CE-63B, 20 gave permission to have their company name and address listed in this publication.

APS, Inc.
195 Clarksville Road
Lawrenceville, New Jersey 08648

AstroPower, Inc.
Solar Park
Newark, Delaware 19716

Blue Ridge Industrial Development Group
304 Viewpoint Drive
Marion, North Carolina 28252

ENTECH, Inc.
PO Box 612246
DFW Airport, Texas 75261

EPV - Energy Photovoltaic
4326 US Route 1
Monmouth Jct., New Jersey 08852

Hoxan America, Inc.
One Centennial Plaza, Suite 3F
Piscataway, New Jersey 08854

Iowa Thin Film Technologies
ISU Research Park #607
Ames, Iowa 50010

Kyocera America, Inc.
8611 Balboa Avenue
San Diego, California 92123

Midway Labs, Inc.
2255 E. 75th Street
Chicago, Illinois 60649

Mobil Solar Energy Corporation
4 Suburban Park Drive
Billerica, Massachusetts 01821

Sanyo Energy Corporation
2001 Sanyo Avenue
San Diego, California 92713

Siemens Solar Industries
PO Box 6032, 4560 Adhor Lane
Camarillo, California 93010

Solarex Corporation
630 Solarex Court
Frederick, Maryland 21701

Solar Electric Engineering, Inc.
116 4th Street
Santa Rosa, California 95401

Solec International, Inc.
12533 Chadron Avenue
Hawthorne, California 90250

Spire Corporation
One Patriots Park
Bedford, Massachusetts 01730

SunPower Corporation
435 Indio Way
Sunnyvale, California 94086

Sunwatt Corporation
RFD Box 751
Addison, Maine 04606

Tideland Signal Corporation
PO Box 52430
Houston, Texas 77052

Translumin International, Inc.
1401 Northwest Boulevard
Franklin, Louisiana 70538

Appendix E

U.S. Customary Units of Measurement, International System of Units (SI), and Selected Data Tables in SI Metric Units

Appendix E

U.S. Customary Units of Measurement, International System of Units (SI), and Selected Data Tables in SI Metric Units

The standard factor for conversion between U.S. customary units and the International System of Units (SI) is shown in Table E1.

Table E1. Conversion Factor for U.S. Customary Units and SI Metric Units of Measurement

To Convert From:	To:	Multiply by:
Area		
Square Feet (ft ²)	Square Meters (m ²)	0.09290304

Note: The conversion factor is exact and all subsequent digits are zero.

Source: Table E1 is patterned after Table 3, "Conversion Factors for SI Metric Units and U.S. Customary Units of Measurement," in S.M. Long and A.M. Orellana, "The Metric System," in *Suggestions to Authors of the Reports of the United States Geological Survey*, Sixth Edition (U.S. Government Printing Office, Washington, DC, 1978), pp. 192-196.

Selected Tables Converted to SI Metric Values

The seven tables listed below contain data converted to equivalent metric values. The crosswalk given below shows the correlation between the tables of metric values and their corresponding tables in U.S. customary units in Chapter 1 of this report. No data tables from the "Photovoltaic Cell and Module Manufacturing Activities" chapter are converted to equivalent metric values.

Appendix E Table Number	Chapter 1 Table Number
E2	Table 1
E3	Table 7
E4	Table 9
E5	Table 10
E6	Table 11
E7	Table 12
E8	Table 13

Table E2. Solar Thermal Collector Companies and Shipments, 1974-1992
(Thousand Square Meters)

Year	Number of Companies	Solar Thermal Collectors		
		Total Shipments	Import Shipments	Export Shipments
1992	45	658	153	29
1991	48	611	143	31
1990	51	1,060	145	23
1989	44	1,067	115	43
1988	51	759	76	15
1987	59	675	64	17
1986	98	870	44	21
1985 ^a	NA	NA	NA	NA
1984	225	1,597	58	32
1983 ^b	203	1,563	47	15
1982 ^b	265	1,730	39	42
1981 ^b	203	1,870	18	72
1980 ^b	233	1,802	22	104
1979	349	1,324	27	79
1978	340	1,009	37	78
1977	321	958	NA	NA
1976	186	539	NA	NA
1975	131	348	NA	NA
1974	45	118	NA	NA

^aIncomplete data (see Appendix A).

^bIncludes imputation of shipment data to account for nonrespondents (see Appendix A).

NA = Not available.

Note: Total shipments include import and export shipments.

Sources: **1974-1977**—Federal Energy Administration telephone survey. **1978-1984**—Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." **1985-1992**—Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table E3. Five Top Solar Thermal Manufacturing States/Territories, 1991 and 1992
(Thousand Square Meters)

Rank	Origin	Shipments ^a	
		1992	1991
1 / 1	California	277	262
2 / 2	New York	91	91
3 / 3	New Jersey	90	75
4 / 5	Florida	19	19
5 / 4	Puerto Rico	19	14
Top Five Total		496	461

^aIncludes domestic shipments and exports.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table E4. Solar Thermal Collector Shipments by Type, 1980-1992
(Thousand Square Meters)

Year	Low-Temperature		Medium-Temperature		High-Temperature ^a
	Shipments	Average Annual Shipments per Manufacturer	Shipments	Average Annual Shipments per Manufacturer	Shipments
1992	575	35.9	83	2.5	(s)
1991	519	32.4	92	2.2	(s)
1990	339	28.2	235	5.7	487
1989	398	39.8	185	5.1	484
1988	309	38.6	68	1.5	382
1987	293	24.4	89	1.8	293
1986	348	15.8	103	1.2	418
1985 ^b	NA	--	NA	--	NA
1984	416	8.7	1,109	5.4	72
1983 ^c	451	8.2	1,113	6.2	NA
1982 ^c	695	11.4	1,035	4.2	NA
1981 ^c	806	10.7	1,064	4.1	NA
1980 ^c	1,136	14.4	666	2.7	NA

^aFor high-temperature collectors, average annual shipments per manufacturer are not disclosed.

^bIncomplete data (see Appendix A).

^cIncludes shipment data imputed for nonrespondents (see Appendix A).

(s) = Less than 500 square meters. NA = Not available. -- = Not applicable.

Note: Totals may not equal sum of components due to independent rounding.

Sources: **1980-1984**—Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." **1985-1992**—Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table E5. Quantity, Value, and Average Price of Solar Thermal Collector Shipments by Type, 1991 and 1992

Type	1992			1991		
	Quantity (thousand square meters)	Value (thousand dollars)	Average Price (dollars per square meter)	Quantity (thousand square meters)	Value (thousand dollars)	Average Price (dollars per square meter)
Low-Temperature						
Liquid and Air	575	15,403	26.80	519	16,206	31.24
Medium-Temperature						
Air	(s)	8	124.59	W	W	W
Liquid						
ICS/Thermosiphon	28	3,825	136.08	24	4,965	205.33
Flat Plate	54	5,441	100.31	65	6,375	97.62
Evacuated Tube	W	W	W	W	W	W
Concentrator	W	W	W	(s)	275	2,355.03
All Medium Temperature	83	9,831	117.95	92	11,807	128.56
High-Temperature						
Parabolic Dish and Trough ...	(s)	148	814.95	(s)	23	343.85
Total	658	25,382	--	611	28,036	--

W = Data withheld to avoid disclosure. (s) = Less than 500 square meters. -- = Not applicable.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table E6. Shipments of Solar Thermal Collectors by End Use and Type, 1991 and 1992
(Thousand Square Meters)

End Use	Low-Temperature	Medium-Temperature					High-Temperature	1992 Total	1991 Total
	Liquid/Air	Liquid					Parabolic Dish/Trough		
	Metallic and Nonmetallic	Air	ICS/Thermosiphon	Flat-Plate (Pumped)	Evacuated Tube	Concentrator			
Pool Heating	574	0	0	3	0	0	0	577	514
Hot Water	0	(s)	26	48	W	W	0	74	92
Space Heating	1	(s)	2	0	(s)	0	0	3	2
Space Cooling	0	0	0	0	W	W	(s)	(s)	(s)
Combined Space and Water Heating	0	0	0	(s)	(s)	0	0	(s)	1
Process Heating	0	0	(s)	3	0	0	(s)	3	1
Electricity Generation	0	0	0	(s)	0	0	(s)	(s)	(s)
Other	0	0	0	0	0	0	(s)	(s)	(s)
Total	575	(s)	28	54	W	W	(s)	658	611

ICS = Integral Collector Storage.

(s) = Less than 500 square meters. W = Data withheld to avoid disclosure.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table E7. Shipments of Solar Thermal Collectors by Market and Type, 1991 and 1992
(Thousand Square Meters)

Market Sector	Low-Temperature	Medium-Temperature					High-Temperature	1992 Total	1991 Total
	Liquid/Air	Liquid					Parabolic Dish/Trough		
	Metallic and Nonmetallic	Air	ICS/Thermo-siphon	Flat-Plate (Pumped)	Evacu-ated Tube	Concen-trator			
Residential	559	(s)	27	47	W	W	0	634	587
Commercial	15	0	(s)	4	W	W	0	19	21
Industrial	1	0	(s)	1	0	0	0	3	1
Utility	0	0	(s)	1	0	0	0	2	1
Other	0	0	(s)	(s)	0	0	(s)	(s)	(s)
Total	575	(s)	28	54	W	W	(s)	658	611

ICS = Integral Collector Storage.

(s) = Less than 500 square meters. W = Data withheld to avoid disclosure.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table E8. Shipments of Solar Thermal Collectors by Destination, 1991 and 1992

Shipments (square meters)			Shipments (square meters)		
Destination	1992	1991	Destination	1992	1991
Alabama	174	2,910	Nebraska	162	113
Alaska	0	0	Nevada	7,285	2,456
Arizona	19,485	15,623	<u>New Hampshire</u>	182	78
Arkansas	189	119	New Jersey	6,245	5,095
<u>California</u>	165,119	202,274	New Mexico	831	3,015
Colorado	4,150	4,006	New York	6,342	4,617
Connecticut	1,071	1,410	North Carolina	521	273
Delaware	0	0	<u>North Dakota</u>	0	0
District of Columbia	0	2	Ohio	1,071	195
Florida	353,529	255,926	<u>Oklahoma</u>	9	189
Georgia	2,587	2,906	<u>Oregon</u>	7,658	11,576
Hawaii	15,770	22,307	Pennsylvania	2,723	2,264
<u>Idaho</u>	9	1	Puerto Rico	18,821	19,321
Illinois	1,980	344	Rhode Island	452	1,121
<u>Indiana</u>	909	144	South Carolina	181	158
<u>Iowa</u>	12	45	<u>South Dakota</u>	0	0
Kansas	177	0	Tennessee	162	150
Kentucky	0	140	Texas	1,750	13,673
Louisiana	162	1,506	<u>Utah</u>	4	0
Maine	239	1,508	Vermont	181	21
Maryland	1,072	120	Virgin Islands (U.S.)	691	1
Massachusetts	1,124	921	Virginia	314	266
Michigan	4	138	Washington	2,825	16
Minnesota	844	1,175	West Virginia	15	13
Mississippi	0	112	Wisconsin	1,753	1,398
Missouri	162	113	Wyoming	0	0
Montana	0	137			
Shipments to United States/Territories				628,946	579,897
Total Shipments				658,283	610,739

Notes: States in "bold" sponsored incentives for solar thermal collector purchases during 1991 (Solar Energy Industries Association, *Solar Industry Journal*, First Quarter 1992, pp. 16-21). "Underlined" States sponsored incentives during 1992 (Solar Energy Industries Association, *Solar Industry Journal*, First Quarter 1993, pp. 21-28).

Source: Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Appendix F

Solar Collector Installed Capacity and Energy Production in the United States

Parabolic troughs (high-temperature solar thermal collectors) operating at a Solar Electric Generating System (SEGS) plant in Kramer Junction, California.

Appendix F

Solar Collector Installed Capacity and Energy Production in the United States

Information on the amount of solar collectors, solar thermal, and photovoltaics shipped for installation has been reported in this series of reports, "Solar Collector Manufacturing Activity." Solar thermal collectors are quantified by area (square feet). Photovoltaic cells and modules are quantified by the amount of electrical capacity (peak watts).

Since 1974, approximately 212 million square feet of solar thermal collectors were shipped for eventual installation in the United States (Table F1). Solar thermal collectors are grouped into three categories: low-temperature, medium-temperature, and high-temperature. Presuming an overall efficiency of 50 percent for all three categories and a 1,500 Btu per square foot average daily insolation, the potential thermal energy production from the 212 million square feet of solar thermal collectors is 0.058 quadrillion Btu (quads) in 1992.

An efficiency of 50 percent for solar thermal collectors exposed to 1,500 Btu insolation is a simplified approach for this energy calculation. Low-temperature and high-temperature collectors have been rated at more than 50 percent efficient, and medium-temperature collectors are generally less than 50 percent efficient. A mildly cloudy day produces about 1,500 Btu of insolation onto an area of 1 square foot.

In 1991, U.S. nonutility power producers reported installed capacity of 360 megawatts and gross electricity generation of 779 million kilowatthours (the thermal energy equivalent is 0.008 Quad) from solar thermal collectors.⁵ Ninety-eight percent of the installed capacity was SEGS I-IX (nine operating Solar Electric Generating System plants in southern California with an installed capacity of 354 megawatts). A 10th SEGS plant (SEGS X) was never constructed as planned in

Table F1. Annual Photovoltaic and Solar Thermal Domestic Shipments, 1974-1992

Year	Domestic Shipments ^a	
	Photovoltaic (peak kilowatts)	Solar Thermal (thousand square feet)
Total, 1974-1992	63,593	212,471
1992	5,760	6,770
1991	6,035	6,242
1990	6,293	11,164
1989	5,462	11,021
1988	4,318	8,016
1987	3,029	7,087
1986	3,224	9,136
1985	4,099	E19,166
1984	7,759	16,843
1983	10,717	16,669
1982	6,897	18,166
1981	--	19,362
1980	--	18,283
1979	--	13,396
1978	--	10,020
1977	--	10,312
1976	--	5,801
1975	--	3,743
1974	--	1,274

^aTotal shipments minus export shipments.

E = Estimated data (see Appendix A, pages 24 and 25).

-- = Not applicable.

Sources: **1974-1977**—Federal Energy Administration telephone survey. **1978-1984**—Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." **1985-1992**—Energy Information Administration, Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey," and Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

⁵EIA, *Annual Energy Review* (June 1993), Table 8.12.

1991. Solar installed capacity from nonutility power producers in 1992 has not yet been published, but it should be about the same as in 1991.

Since 1982, approximately 64 peak megawatts of photovoltaic cells and modules were shipped for eventual installation in the United States (Table F1). Assuming a 27.5 percent capacity factor,⁶ the potential energy production from the 64 peak megawatts is 155 million kilowatthours of electricity. This is equivalent to 0.002 Quad of thermal energy in 1992, using a thermal conversion rate of 10,352 Btu per kilowatthour of electricity generation.⁷

U.S. electric utilities reported that net electric generation from photovoltaic modules was 3.2 million kilowatthours in 1992⁸ (Table F2). Net generation is gross generation minus plant use by all electric utility-owned plants.

Table F2. U.S. Utility Net Electricity Generation from Solar Energy, 1992
(Thousand Kilowatthours)

Utility	Plant (State)	Net Generation
Sacramento Municipal Utility District	Solar (California)	2,467
Austin Electric	Decker Creek (Texas)	369
Pacific Gas & Electric	PVUSA 1 (California)	322
Virginia Electric Power	North Anna (Virginia)	11
Total		3,169

Source: Energy Information Administration, *Electric Power Monthly*, April 1993, DOE/EIA-0226(93/04), Table 64

Estimated U.S. solar electricity generation was 937.2 million kilowatthours in 1992. Overall, estimated solar energy production was 0.06 Quad, and adjusted total energy production in the United States was 66.78 Quads (Table F3).

Table F3. Estimated U.S. Solar and Total Energy Production, 1992
(Quadrillion Btu)

Activity, Production Sector, and Solar Energy Source	Energy Production
Production to Generate Electricity	
Electric Utilities	
Photovoltaic	(s)
Nonutility Power Producers	
Solar Thermal-Electric	0.01
End Users	
Photovoltaic	(s)
Production to Generate Thermal Energy	
End Users	
Solar Thermal	0.05
Estimated Solar Energy Production	0.06
Adjusted Production Estimate	*66.78

*Adjusted total is the sum of EIA's total energy production estimate of 66.72 Quadrillion Btu (*Annual Energy Review* 1992, Table 1.2) and 0.06 Quadrillion Btu estimated for solar energy production.

(s) = Less than 0.005 quadrillion Btu

Sources: Energy Information Administration (EIA), Form CE-63A, "Annual Solar Thermal Collector Manufacturers Survey," and Form CE-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey," EIA, Form EIA-759, "Monthly Power Plant Report," EIA, *Annual Energy Review* 1992 (June 1993), Table 1.2 and Table 8.12

⁶Department of Energy, "The Potential of Renewable Energy, An Interlaboratory White Paper" (March 1990), p. C-5

⁷EIA, *Annual Energy Review* 1993 (June 1993), Table A7

⁸EIA, Form EIA-759, "Monthly Power Plant Report."

Glossary

Glossary

Air Collector: A medium-temperature solar thermal collector, employed predominantly in space-heating applications, which uses pumped air as the heat-transfer medium.

Amorphous Silicon: An alloy of silica and hydrogen, with an irregular internal atomic arrangement, that can be deposited in thin-film layers (a few micrometers in thickness) by means of a number of deposition methods to produce thin-film photovoltaic cells on glass, metal, or plastic substrates.

Btu (British Thermal Unit): A standard unit for measuring the quantity of heat energy equal to the quantity of heat required to raise the temperature of 1 pound of water by 1 degree Fahrenheit.

Cast Silicon: Crystalline silicon obtained by pouring pure molten silicon into a vertical mold and adjusting the temperature gradient along the mold volume during cooling to obtain slow, vertically advancing crystallization of the silicon. The polycrystalline ingot thus formed is composed of large, relatively parallel, interlocking crystals. The cast ingots are sawed into wafers for further fabrication into photovoltaic cells. Cast-silicon wafers and ribbon-silicon sheets fabricated into cells are usually referred to as polycrystalline photovoltaic cells.

Concentrator: A reflective or refractive device that focuses solar rays onto an area smaller than the reflective or refractive surface, resulting in higher intensity solar rays at the point of focus.

Consumer Goods: Goods such as calculators, computers, toys, and watches that are powered by photovoltaic cells and modules.

Evacuated-Tube Collector: A solar thermal collector in which the collector fluid flows through an absorber tube that is contained inside an evacuated glass cylinder.

Export (solar): A shipment of solar thermal collectors and/or photovoltaic devices sent from the United States and any of its territories to a foreign country.

Flat-Plate (pumped): A medium-temperature solar thermal collector, typically made with a metal frame, glazing, absorbers (usually metal), and insulation, that uses pumped liquid as the heat-transfer medium; predominately used in water-heating applications.

Generation (Electricity): The process of producing electric energy by transforming other forms of energy; also, the amount of electric energy produced, expressed in watt-hours (Wh).

Gross Generation: The total amount of electric energy produced by the generating units at a generating station or stations, measured at the generator terminals.

High-Temperature Collector: A solar thermal collector that generally operates at temperatures above 180 degrees Fahrenheit.

Import (solar): A shipment of solar thermal collectors and/or photovoltaic devices into the United States and any of its territories from foreign countries.

Integral Collector Storage (ICS): A solar thermal collector in which incident solar radiation is absorbed directly by the storage medium.

Kilowatthour (Kwh): One thousand watt-hours.

Liquid Collector: A medium-temperature solar thermal collector, employed predominantly in water heating, which uses pumped liquid as the heat-transfer medium.

Low-Temperature Collector: A solar thermal collector that generally operates at temperatures below 110 degrees Fahrenheit.

Medium-Temperature Collector: A solar thermal collector that generally operates in the temperature range of 140 degrees Fahrenheit to 180 degrees Fahrenheit but can also operate at temperatures as low as 110 degrees Fahrenheit.

Net Generation: Gross generation less the electric energy consumed at the generating station for station use.

One Sun: Natural solar insulation falling on an object without concentration or diffusion of the solar rays.

Original Equipment Manufacturer (OEM): A non-photovoltaic manufacturer that combines photovoltaic technology into existing or newly developed product lines.

Parabolic Dish: A high-temperature (above 180 degrees Fahrenheit) solar thermal concentrator, generally bowl-shaped, with the capacity for tracking the sun using two axes of rotation.

Parabolic Trough: A high-temperature (above 180 degrees Fahrenheit) solar thermal concentrator with the capacity for tracking the sun using one axis of rotation.

Peak Kilowatt: One thousand peak watts.

Peak Megawatt: One million peak watts.

Peak Watt: A manufacturer's unit indicating the amount of power a photovoltaic cell or module will produce at standard test conditions (normally 1,000 watts per square meter and 25 degrees Celsius).

Photovoltaic Cell: An electronic device consisting of layers of semiconductor materials fabricated to form a junction (adjacent layers of materials with different electronic characteristics) and electrical contacts, and being capable of converting incident light directly into electricity (direct current).

Photovoltaic Module: An integrated assembly of interconnected photovoltaic cells designed to deliver a selected level of working voltage and current at its output terminals, packaged for protection against environmental degradation, and suited for incorporation in photovoltaic power systems.

Ribbon Silicon: Sheets of crystalline silicon fabricated by a variety of solidification (crystallization) methods

whereby thin silicon sheets are withdrawn from a pool of relatively pure molten silicon. The methods include: edge-defined, film-fed growth (EFG) and dendritic-web growth.

Single-Crystal Silicon: An extremely pure form of crystalline silicon produced by dipping a single crystal seed into a pool of molten silicon under high vacuum conditions and slowly withdrawing a solidifying single crystal boule (rod) of silicon. The boule is sawed into thin silicon wafers and fabricated into single-crystal photovoltaic cells.

Solar Thermal Collector: A device designed to receive solar radiation and convert it into thermal energy. Normally, a solar thermal collector includes a frame, glazing, and an absorber, together with appropriate insulation. The heat collected by the solar thermal collector may be used immediately or stored for later use.

Special Collector: An evacuated tube collector or a concentrating (focusing) collector. Special collectors operate in the temperature range from just above ambient temperature (low concentration for pool heating) to several hundred degrees Fahrenheit (high concentration for air conditioning and specialized industrial processes).

Survey Frame: The list of companies to which survey forms are sent.

Thermosiphon System: A solar collector system for water heating in which circulation of the collection fluid through the storage loop is provided solely by the temperature and density difference between the hot and cold fluids.

Watt-hour (Wh): An electrical energy unit of measure equal to 1 watt of power supplied to, or taken from, an electric circuit steadily for 1 hour.

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